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n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
1.0	3.142	0.7854	1.000	1.000	1.0000	1.0000
1.1	3.456	0.9503	1.210	1.331	1.0488	1.0323
1.2	3.770	1.1310	1.440	1.728	1.0955	1.0627
1.3	4.084	1.3273	1.690	2.197	1.1402	1.0914
1.4	4.398	1.5394	1.960	2.744	1.1832	1.1187
1.5	4.712	1.7672	2.250	3.375	1.2247	1.1447
1.6	5.027	2.0106	2.560	4.096	1.2649	1.1696
1.7	5.341	2.2698	2.890	4.913	1.3038	1.1935
1.8	5.655	2.5447	3.240	5.832	1.3416	1.2164
1.9	5.969	2.8353	3.610	6.859	1.3784	1.2386
2.0	6.283	3.1416	4.000	8.000	1.4142	1.2599
2.1	6.597	3.4636	4.410	9.261	1.4491	1.2806
2.2	6.912	3.8013	4.840	10.648	1.4832	1.3006
2.3	7.226	4.1548	5.290	12.167	1.5166	1.3200
2.4	7.540	4.5239	5.760	13.824	1.5492	1.3389
2.5	7.854	4.9087	6.250	15.625	1.5811	1.3572
2.6	8.168	5.3093	6.760	17.576	1.6125	1.3751
2.7	8.482	5.7256	7.290	19.683	1.6432	1.3925
2.8	8.797	6.1575	7.840	21.952	1.6733	1.4095
2.9	9.111	6.6052	8.410	24.389	1.7029	1.4260
3.0	9.425	7.0686	9.00	27.000	1.7321	1.4422
3.1	9.739	7.5477	9.61	29.791	1.7607	1.4581
3.2	10.053	8.0425	10.24	32.768	1.7889	1.4736
3.3	10.367	8.5530	10.89	35.937	1.8166	1.4888
3.4	10.681	9.0792	11.56	39.304	1.8439	1.5037
3.5	10.996	9.6211	12.25	42.875	1.8708	1.5183
3.6	11.310	10.179	12.96	46.656	1.8974	1.5326
3.7	11.624	10.752	13.69	50.653	1.9235	1.5467
3.8	11.938	11.341	14.44	54.872	1.9494	1.5605
3.9	12.252	11.946	15.21	59.319	1.9748	1.5741
4.0	12.566	12.566	16.00	64.000	2.0000	1.5874
4.1	12.881	13.203	16.81	68.921	2.0249	1.6005
4.2	13.195	13.854	17.64	74.088	2.0494	1.6134
4.3	13.509	14.522	18.49	79.507	2.0736	1.6261
4.4	13.823	15.205	19.36	85.184	2.0976	1.6386
4.5	14.137	15.904	20.25	91.125	2.1213	1.6510
4.6	14.451	16.619	21.16	97.336	2.1448	1.6631
4.7	14.765	17.349	22.09	103.823	2.1680	1.6751

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
4.8	15.080	18.096	23.04	110.592	2.1909	1.6869
4.9	15.394	18.857	24.01	117.649	2.2136	1.6985
5.0	15.708	19.635	25.00	125.000	2.2361	1.7100
5.1	16.022	20.428	26.01	132.651	2.2583	1.7213
5.2	16.336	21.237	27.04	140.608	2.2804	1.7325
5.3	16.650	22.062	28.09	148.877	2.3022	1.7435
5.4	16.965	22.902	29.16	157.464	2.3238	1.7544
5.5	17.279	23.758	30.25	166.375	2.3452	1.7652
5.6	17.593	24.630	31.36	175.616	2.3664	1.7758
5.7	17.907	25.518	32.49	185.193	2.3875	1.7863
5.8	18.221	26.421	33.64	195.112	2.4083	1.7967
5.9	18.535	27.340	34.81	205.379	2.4290	1.8070
6.0	18.850	28.274	36.00	216.000	2.4495	1.8171
6.1	19.164	29.225	37.21	226.981	2.4698	1.8272
6.2	19.478	30.191	38.44	238.328	2.4900	1.8371
6.3	19.792	31.173	39.69	250.047	2.5100	1.8469
6.4	20.106	32.170	40.96	262.144	2.5298	1.8566
6.5	20.420	33.183	42.25	274.625	2.5495	1.8663
6.6	20.735	34.212	43.56	287.496	2.5691	1.8758
6.7	21.049	35.257	44.89	300.763	2.5884	1.8852
6.8	21.363	36.317	46.24	314.432	2.6077	1.8945
6.9	21.677	37.393	47.61	328.509	2.6268	1.9038
7.0	21.991	38.485	49.00	343.000	2.6458	1.9129
7.1	22.305	39.592	50.41	357.911	2.6646	1.9220
7.2	22.619	40.715	51.84	373.248	2.6833	1.9310
7.3	22.934	41.854	53.29	389.017	2.7019	1.9399
7.4	23.248	43.008	54.76	405.224	2.7203	1.9487
7.5	23.562	44.179	56.25	421.875	2.7386	1.9574
7.6	23.876	45.365	57.76	438.976	2.7568	1.9661
7.7	24.190	46.566	59.29	456.533	2.7749	1.9747
7.8	24.504	47.784	60.84	474.552	2.7929	1.9832
7.9	24.819	49.017	62.41	493.039	2.8107	1.9916
8.0	25.133	50.266	64.00	512.000	2.8284	2.0000
8.1	25.447	51.530	65.61	531.441	2.8461	2.0083
8.2	25.761	52.810	67.24	551.468	2.8636	2.0165
8.3	26.075	54.106	68.89	571.787	2.8810	2.0247
8.4	26.389	55.418	70.56	592.704	2.8983	2.0328
8.5	26.704	56.745	72.25	614.125	2.9155	2.0408
8.6	27.018	58.088	73.96	636.056	2.9326	2.0488
8.7	27.332	59.447	75.69	658.503	2.9496	2.0567
8.8	27.646	60.821	77.44	681.473	2.9665	2.0646
8.9	27.960	62.211	79.21	704.969	2.9833	2.0724

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
9.0	28.274	63.617	81.00	729.000	3.0000	2.0801
9.1	28.588	65.039	82.81	753.571	3.0166	2.0878
9.2	28.903	66.476	84.64	778.688	3.0332	2.0954
9.3	29.217	67.929	86.49	804.357	3.0496	2.1029
9.4	29.531	69.398	88.36	830.584	3.0659	2.1105
9.5	29.845	70.882	90.25	857.375	3.0822	2.1179
9.6	30.159	72.382	92.16	884.736	3.0984	2.1253
9.7	30.473	73.898	94.09	912.673	3.1145	2.1327
9.8	30.788	75.430	96.04	941.192	3.1305	2.1400
9.9	31.102	76.977	98.01	970.299	3.1464	2.1472
10.0	31.416	78.540	100.00	1000.000	3.1623	2.1544
10.1	31.730	80.119	102.01	1030.301	3.1780	2.1616
10.2	32.044	81.713	104.04	1061.208	3.1937	2.1687
10.3	32.358	83.323	106.09	1092.727	3.2094	2.1757
10.4	32.673	84.949	108.16	1124.863	3.2249	2.1828
10.5	32.987	86.590	110.25	1157.625	3.2404	2.1897
10.6	33.301	88.247	112.36	1191.016	3.2558	2.1967
10.7	33.615	89.920	114.49	1225.043	3.2711	2.2036
10.8	33.929	91.609	116.64	1259.712	3.2863	2.2104
10.9	34.243	93.313	118.81	1295.029	3.3015	2.2172
11.0	34.558	95.033	121.00	1331.000	3.3166	2.2239
11.1	34.872	96.769	123.21	1367.631	3.3317	2.2307
11.2	35.186	98.520	125.44	1404.928	3.3466	2.2374
11.3	35.500	100.29	127.69	1442.897	3.3615	2.2441
11.4	35.814	102.07	129.96	1481.544	3.3764	2.2506
11.5	36.128	103.87	132.25	1520.875	3.3912	2.2572
11.6	36.442	105.68	134.56	1560.896	3.4059	2.2637
11.7	36.757	107.51	136.89	1601.613	3.4205	2.2702
11.8	37.071	109.36	139.24	1643.032	3.4351	2.2766
11.9	37.385	111.22	141.61	1685.159	3.4496	2.2831
12.0	37.699	113.10	144.00	1728.000	3.4641	2.2894
12.1	38.013	114.99	146.41	1771.561	3.4785	2.2957
12.2	38.327	116.90	148.84	1815.848	3.4928	2.3021
12.3	38.642	118.82	151.29	1860.867	3.5071	2.3084
12.4	38.956	120.76	153.76	1906.624	3.5214	2.3146
12.5	39.270	122.72	156.25	1953.125	3.5355	2.3208
12.6	39.584	124.69	158.76	2000.376	3.5496	2.3270
12.7	39.898	126.68	161.29	2048.383	3.5637	2.3331
12.8	40.212	128.68	163.84	2097.152	3.5777	2.3392
12.9	40.527	130.70	166.41	2146.689	3.5917	2.3453
13.0	40.841	132.73	169.00	2197.000	3.6056	2.3513
13.1	41.155	134.78	171.61	2248.091	3.6194	2.3573
13.2	41.469	136.85	174.24	2299.968	3.6332	2.3633

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
13.3	41.783	138.93	176.89	2352.637	3.6469	2.3693
13.4	42.097	141.03	179.56	2406.104	3.6606	2.3752
13.5	42.412	143.14	182.25	2460.375	3.6742	2.3811
13.6	42.726	145.27	184.96	2515.456	3.6878	2.3870
13.7	43.040	147.41	187.69	2571.353	3.7013	2.3928
13.8	43.354	149.57	190.44	2628.072	3.7148	2.3986
13.9	43.668	151.75	193.21	2685.619	3.7283	2.4044
14.0	43.982	153.94	196.00	2744.000	3.7417	2.4101
14.1	44.296	156.15	198.81	2803.221	3.7550	2.4159
14.2	44.611	158.37	201.64	2863.288	3.7683	2.4216
14.3	44.925	160.61	204.49	2924.207	3.7815	2.4272
14.4	45.239	162.86	207.36	2985.984	3.7947	2.4329
14.5	45.553	165.13	210.25	3048.625	3.8079	2.4385
14.6	45.867	167.42	213.16	3112.136	3.8210	2.4441
14.7	46.181	169.72	216.09	3176.523	3.8341	2.4497
14.8	46.496	172.03	219.04	3241.792	3.8471	2.4552
14.9	46.810	174.37	222.01	3307.949	3.8600	2.4607
15.0	47.124	176.72	225.00	3375.000	3.8730	2.4662
15.1	47.438	179.08	228.01	3442.951	3.8859	2.4717
15.2	47.752	181.46	231.04	3511.808	3.8987	2.4772
15.3	48.066	183.85	234.09	3581.577	3.9115	2.4825
15.4	48.381	186.27	237.16	3652.264	3.9243	2.4879
15.5	48.695	188.69	240.25	3723.875	3.9370	2.4933
15.6	49.009	191.13	243.36	3796.416	3.9497	2.4986
15.7	49.323	193.59	246.49	3869.893	3.9623	2.5039
15.8	49.637	196.07	249.64	3944.312	3.9749	2.5092
15.9	49.951	198.56	252.81	4019.679	3.9875	2.5146
16.0	50.265	201.06	256.00	4096.000	4.0000	2.5198
16.1	50.580	203.58	259.21	4173.281	4.0125	2.5251
16.2	50.894	206.12	262.44	4251.528	4.0249	2.5303
16.3	51.208	208.67	265.69	4330.747	4.0373	2.5355
16.4	51.522	211.24	268.96	4410.944	4.0497	2.5406
16.5	51.836	213.83	272.25	4492.125	4.0620	2.5458
16.6	52.150	216.42	275.56	4574.296	4.0743	2.5509
16.7	52.465	219.04	278.89	4657.463	4.0866	2.5561
16.8	52.779	221.67	282.24	4741.632	4.0988	2.5612
16.9	53.093	224.32	285.61	4826.809	4.1110	2.5663
17.0	53.407	226 98	289.00	4913.000	4.1231	2.5713
17.1	53.721	229.66	292.41	5000.211	4.1352	2.5763
17.2	54.035	132.35	295.84	5088.448	4.1473	2.5813
17.3	54.350	235.06	299.29	5177.717	4.1593	2.5863
17.4	54.664	237.79	302.76	5268.024	4.1713	2.5913

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
17.5	54.978	240.53	306.25	5359.375	4.1833	2.5963
17.6	55.292	243.29	309.76	5451.776	4.1952	2.6012
17.7	55.606	246.06	313.29	5545.233	4.2071	2.6061
17.8	55.920	248.85	316.84	5639.752	4.2190	2.6109
17.9	56.235	251.65	320.41	5735.339	4.2308	2.6158
18.0	56.549	254.47	324.00	5832.000	4.2426	2.6207
18.1	56.863	257.30	327.61	5929.741	4.2544	2.6256
18.2	57.177	260.16	331.24	6028.568	4.2661	2.6304
18.3	57.491	263.02	334.89	6128.487	4.2778	2.6352
18.4	57.805	265.90	338.56	6229.504	4.2895	2.6401
18.5	58.119	268.80	342.25	6331.625	4.3012	2.6448
18.6	58.434	271.72	345.96	6434.856	4.3128	2.6495
18.7	58.748	274.65	349.69	6539.203	4.3243	2.6543
18.8	59.062	277.59	353.44	6644.672	4.3359	2.6590
18.9	59.376	280.55	357.21	6751.269	4.3474	2.6637
19.0	59.690	283.53	361.00	6859.000	4.3589	2.6684
19.1	60.004	286.52	364.81	6967.871	4.3703	2.6731
19.2	60.319	289.53	368.64	7077.888	4.3818	2.6777
19.3	60.633	292.55	372.49	7189.057	4.3932	2.6824
19.4	60.947	295.59	376.36	7301.384	4.4045	2.6869
19.5	61.261	298.65	380.25	7414.875	4.4159	2.6916
19.6	61.575	301.72	384.16	7529.536	4.4272	2.6962
19.7	61.889	304.81	388.09	7645.373	4.4385	2.7008
19.8	62.204	307.91	392.04	7762.392	4.4497	2.7053
19.9	62.518	311.03	396.01	7880.599	4.4609	2.7098
20.0	62.832	314.16	400.00	8000.000	4.4721	2.7144
20.1	63.146	317.31	404.01	8120.601	4.4833	2.7189
20.2	63.460	320.47	408.04	8242.408	4.4944	2.7234
20.3	63.774	323.66	412.09	8365.427	4.5055	2.7279
20.4	64.088	326.85	416.16	8489.664	4.5166	2.7324
20.5	64.403	330.06	420.25	8615.125	4.5277	2.7368
20.6	64.717	333.29	424.36	8741.816	4.5387	2.7413
20.7	65.031	336.54	428.49	8869.743	4.5497	2.7457
20.8	65.345	339.80	432.64	8989.912	4.5607	2.7502
20.9	05.659	343.07	436.81	9129.329	4.5716	2.7545
21.0	65.973	346.36	441.00	9261.000	4.5826	2.7589
21.1	66.288	349.67	445.21	9393.931	4.5935	2.7633
21.2	66.602	352.99	449.44	9528.128	4.6043	2.7676
21.3	66.916	356.33	453.69	9663.597	4.6152	2.7720
21.4	67.230	359.68	457.96	9800.344	4.6260	2.7763
21.5	67.544	363.05	462.25	9938.375	4.6368	2.7806
21.6	67.858	366.44	466.56	10077.696	4.6476	2.7849
21.7	68.173	369.84	470.89	10218.313	4.6583	2.7893

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
21.8	68.487	373.25	475.24	10360.232	4.6690	2.7935
21.9	68.801	376.69	479.61	10503.459	4.6797	2.7978
22.0	69.115	380.13	484.00	10648.000	4.6904	2.8021
22.1	69.429	383.60	488.41	10793.861	4.7011	2.8063
22.2	69.743	387.08	492.84	10941.048	4.7117	2.8105
22.3	70.058	390.57	497.29	11089.567	4.7223	2.8147
22.4	70.372	394.08	501.76	11239.424	4.7329	2.8189
22.5	70.686	397.61	506.25	11390.625	4.7434	2.8231
22.6	71.000	401.15	510.76	11543.176	4.7539	2.8273
22.7	71.314	404.71	515.29	11697.083	4.7644	2.8314
22.8	71.268	408.28	519.84	11852.352	4.7749	2.8356
22.9	71.942	411.87	524.41	12008.989	4.7854	2.8397
23.0	72.257	415.48	529.00	12167.000	4.7958	2.8438
23.1	72.571	419.10	533.61	12326.391	4.8062	2.8479
23.2	72.885	422.73	538.24	12487.168	4.8166	2.8521
23.3	73.199	426.39	542.89	12649.337	4.8270	2.8562
23.4	73.513	430.05	547.56	12812.904	4.8373	2.8603
23.5	73.827	433.74	552.25	12977.875	4.8477	2.8643
23.6	74.142	437.44	556.96	13144.256	4.8580	2.8684
23.7	74.456	441.15	561.69	13312.053	4.8683	2.8724
23.8	74.770	444.88	566.44	13481.272	4.8785	2.8765
23.9	75.084	448.63	571.21	13651.919	4.8888	2.8805
24.0	75.398	452.39	576.00	13824.000	4.8990	2.8845
24.1	75.712	456.17	580.81	13997.521	4.9092	2.8885
24.2	76.027	459.96	585.64	14172.488	4.9193	2.8925
24.3	76.341	463.77	590.49	14348.907	4.9295	2.8965
24.4	76.655	467.60	595.36	14526.784	4.9396	2.9004
24.5	76.969	471.44	600.25	14706.125	4.9497	2.9044
24.6	77.283	475.29	605.16	14886.936	4.9598	2.9083
24.7	77.597	479.16	610.09	15069.223	4.9699	2.9123
24.8	77.911	483.05	615.04	15252.992	4.9799	2.9162
24.9	78.226	486.96	620.01	15438.249	4.9899	2.9201
25.0	78.540	490.87	625.00	15625.000	5.0000	2.9241
25.1	78.854	494.81	630.01	15813.251	5.0099	2.9279
25.2	79.168	498.76	635.04	16003.008	5.0199	2.9318
25.3	79.482	502.73	640.09	16194.277	5.0299	2.9356
25.4	79.796	506.71	645.16	16387.064	5.0398	2.9395
25.5	80.111	510.71	650.25	16581.375	5.0497	2.9434
25.6	80.425	514.72	655.36	16777.216	5.0596	2.9472
25.7	80.739	518.75	660.49	16974.593	5.0695	2.9510
25.8	81.053	522.79	665.64	17173.512	5.0793	2.9549
25.9	81.367	526.85	670.81	17373.979	5.0892	2.9586

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
26.0	81.681	530.93	676.00	17576.000	5.0990	2.9624
26.1	81.996	535.02	681.21	17779.581	5.1088	2.9662
26.2	82.310	539.13	686.44	17984.728	5.1185	2.9701
26.3	82.624	543.25	691.69	18191.447	5.1283	2.9738
26.4	82.938	547.39	696.96	18399.744	5.1380	2.9776
26.5	83.252	551.55	702.25	18609.625	5.1478	2.9814
26.6	83.566	555.72	707.56	18821.096	5.1575	2.9851
26.7	83.881	559.90	712.89	19034.163	5.1672	2.9888
26.8	84.195	564.10	718.24	19248.832	5.1768	2.9926
26.9	84.509	568.32	723.61	19465.109	5.1865	2.9963
27.0	84.823	572.56	729.00	19683.000	5.1962	3.0000
27.1	85.137	576.80	734.41	19902.511	5.2057	3.0037
27.2	85.451	581.07	739.84	20123.648	5.2153	3.0074
27.3	85.765	585.35	745.29	20346.417	5.2249	3.0111
27.4	86.080	589.65	750.76	20570.824	5.2345	3.0147
27.5	86.394	593.96	756.25	20796.875	5.2440	3.0184
27.6	86.708	598.29	761.76	21024.576	5.2535	3.0221
27.7	87.022	602.63	767.29	21253.933	5.2630	3.0257
27.8	87.336	606.99	772.84	21484.952	5.2725	3.0293
27.9	87.650	611.36	778.41	21717.639	5.2820	3.0330
28.0	87.965	615.75	784.00	21952.000	5.2915	3.0366
28.1	88.279	620.16	789.61	22188.041	5.3009	3.0402
28.2	88.593	624.58	795.24	22425.768	5.3103	3.0438
28.3	88.907	629.02	800.89	22 65.187	5.3197	3.0474
28.4	89.221	633.47	806.56	22906.304	5.3291	3.0510
28.5	89.535	637.94	812.25	23149.125	5.3385	3.0546
28.6	89.850	642.42	817.96	23393.656	5.3478	3.0581
28.7	90.164	646.93	823.69	23639.903	5.3572	3.0617
28.8	90.478	651.44	829.44	23887.872	5.3665	3.0652
28.9	90.792	655.97	835.21	24137.569	5.3758	3.0688
29.0	91.106	660.52	841.00	24389.000	5.3852	3.0723
29.1	91.420	665.08	846.81	24642.171	5.3944	3.0758
29.2	91.735	669.66	852.64	24897.088	5.4037	3.0794
29.3	92.049	674.26	858.49	25153.757	5.4129	3.0829
29.4	92.363	678.87	864.36	25412.184	5.4221	3.0864
29.5	92.677	683.49	870.25	25672.375	5.4313	3.0899
29.6	92.991	688.13	876.16	25934.336	5.4405	3.0934
29.7	93.305	692.79	882.09	26198.073	5.4497	3.0968
29.8	93.619	697.47	888.04	26463.592	5.4589	3.1003
29.9	93.934	702.15	894.01	26730.899	5.4680	3.1038
30.0	94.248	706.86	900.00	27000.000	5.4772	3.1072
30.1	94.562	711.58	906.01	27270.901	5.4863	3.1107
30.2	94.876	716.32	912.04	27543.608	5.4954	3.1141

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
30.3	95.190	721.07	918.09	27818.127	5.5045	3.1176
30.4	95.505	725.83	924.16	28094.464	5.5136	3.1210
30.5	95.819	730.62	930.25	28372.625	5.5226	3.1244
30.6	96.133	735.42	936.36	28652.616	5.5317	3.1278
30.7	96.447	740.23	942.49	28934.443	5.5407	3.1312
30.8	96.761	745.06	948.64	29218.112	5.5497	3.1346
30.9	97.075	749.91	954.81	29503.629	5.5587	3.1380
31.0	97.389	754.77	961.00	29791.000	5.5678	3.1414
31.1	97.704	759.65	967.21	30080.231	5.5767	3.1448
31.2	98.018	764.54	973.44	30371.328	5.5857	3.1481
31.3	98.332	769.45	979.69	30664.297	5.5946	3.1515
31.4	98.646	774.37	985.96	30959.144	5.6035	3.1548
31.5	98.960	779.31	992.25	31255.875	5.6124	3.1582
31.6	99.274	784.27	998.56	31554.496	5.6213	3.1615
31.7	99.588	789.24	1004.89	31855.013	5.6302	3.1648
31.8	99.903	794.23	1011.24	32157.432	5.6391	3.1681
31.9	100.22	799.23	1017.61	32461.759	5.6480	3.1715
32.0	100.53	804.25	1024.00	32768.000	5.6569	3.1748
32.1	100.85	809.28	1030.41	33076.161	5.6656	3.1781
32.2	101.16	814.33	1036.84	33386.248	5.6745	3.1814
32.3	101.47	819.40	1043.29	33698.267	5.6833	3.1847
32.4	101.79	824.48	1049.76	34012.224	5.6921	3.1880
32.5	102.10	829.58	1056.25	34328.125	5.7008	3.1913
32.6	102.42	834.69	1062.76	34645.976	5.7096	3.1945
32.7	102.73	839.82	1069.29	34965.783	5.7183	3.1978
32.8	103.04	844.96	1075.84	35287.552	5.7271	3.2010
32.9	103.36	850.12	1082.41	35611.289	5.7358	3.2043
33.0	103.67	855.30	1089.00	35937.000	5.7446	3.2075
33.1	103.99	860.49	1095.61	36264.691	5.7532	3.2108
33.2	104.30	865.70	1102.24	36594.368	5.7619	3.2140
33.3	104.62	870.92	1108.89	36926.037	5.7706	3.2172
33.4	104.93	876.16	1115.56	37259.704	5.7792	3.2204
33.5	105.24	881.41	1122.25	37595.375	5.7879	3.2237
33.6	105.56	886.68	1128.96	37933.056	5.7965	3.2269
33.7	105.87	891.97	1135.69	38272.753	5.8051	3.2301
33.8	106.19	897.27	1142.44	38614.472	5.8137	3.2332
33.9	106.50	902.59	1149.21	38958.219	5.8223	3.2364
34.0	106.81	907.92	1156.00	39304.000	5.8310	3.2396
34.1	107.13	913.27	1162.81	39651.821	5.8395	3.2428
34.2	107.44	918.63	1169.64	40001.688	5.8480	3.2460
34.3	107.76	924.01	1176.49	40353.607	5.8566	3.2491
34.4	108.07	929.41	1183.36	40707.584	5.8651	3.2522

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
34.5	108.38	934.82	1190.25	41063.625	5.8730	3.2554
34.6	108.70	940.25	1197.16	41421.736	5.8821	3.2586
34.7	109.01	945.69	1204.09	41781.923	5.8906	3.2617
34.8	109.33	951.15	1211.04	42144.192	5.8991	3.2648
34.9	109.64	956.62	1218.01	42508.549	5.9076	3.2679
35.0	109.96	962.11	1225.00	42875.000	5.9161	3.2710
35.1	110.27	967.62	1232.01	43243.551	5.9245	3.2742
35.2	110.58	973.14	1239.04	43614.208	5.9329	3.2773
35.3	110.90	978.68	1246.09	43986.977	5.9413	3.2804
35.4	111.21	984.23	1253.16	44361.864	5.9497	3.2835
35.5	111.53	989.80	1260.25	44738.875	5.9581	3.2866
35.6	111.84	995.38	1267.36	45118.016	5.9665	3.2897
35.7	112.15	1000.98	1274.49	45499.293	5.9749	3.2927
35.8	112.47	1006.60	1281.64	45882.712	5.9833	3.2958
35.9	112.78	1012.23	1288.81	46268.279	5.9916	3.2989
36.0	113.10	1017.88	1296.00	46656.000	6.0000	3.3019
36.1	113.41	1023.54	1303.21	47045.881	6.0083	3.3050
36.2	113.73	1029.22	1310.44	47437.928	6.0166	3.3080
36.3	114.04	1034.91	1317.69	47832.147	6.0249	3.3111
36.4	114.35	1040.62	1324.96	48228.544	6.0332	3.3141
39.5	114.67	1046.35	1332.25	48627.125	6.0415	3.3171
36.6	114.98	1052.09	1339.56	49027.896	6.0497	3.3202
36 7	115.30	1057.84	1346.89	49430.863	6.0580	3.3232
36.8	115.61	1063.62	1354.24	49836.032	6.0663	3.3262
36.9	115.92	1069.41	1361.61	50243.409	6.0745	3.3292
37.0	116.24	1075.21	1369.00	50653.000	6.0827	3.3322
37.1	116.55	1081.03	1376.41	51064.811	6.0909	3.3352
37.2	116.87	1086.87	1383.84	51478.848	6.0991	3.3382
37.3	117.18	1092.72	1391.29	51895.117	6.1073	3.3412
37.4	117.50	1098.58	1398.76	52313.624	6.1155	3.3442
37.5	117.81	1104.47	1406.25	52734.375	6.1237	3.3472
37.6	118.12	1110.36	1413.76	53157.376	6.1318	3.3501
37.7	118.44	1116.28	1421.29	53582.633	6.1400	3.3531
37.8	118.75	1122.21	1428.84	54010.152	6.1481	3.3561
37.9	119.07	1128.15	1436.41	54439.939	6.1563	3.3590
38.0	119.38	1134.11	1444.00	54872.000	6.1644	3.3620
38.1	119.69	1140.09	1451.61	55306.341	6.1725	3.3649
38.2	120.01	1146.08	1459.24	55742.968	6.1806	3.3679
38.3	120.32	1152.09	1466.89	56181.887	6.1887	3.3708
38.4	120.64	1158.12	1474.56	56623.104	6.1967	3.3737
38.5	120.95	1164.16	1482.25	57066.625	6.2048	3.3767
38.6	121.27	1170.21	1489.96	57512.456	6.2129	3.3796
38.7	121.58	1176.28	1497.69	57960.603	6.2209	3.3825

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
38.8	121.89	1182.37	1505.44	58411.072	6.2289	3.3854
38.9	122.21	1188.47	1513.21	58863.869	6.2370	3.3883
39.0	122.52	1194.59	1521.00	59319.000	6.2450	3.3912
39.1	122.84	1200.72	1528.81	59776.471	6.2530	3.3941
39.2	123.15	1206.87	1536.64	60236.288	6.2610	3.3970
39.3	123.46	1213.04	1544.49	60698.457	6.2689	3.3999
39.4	123.78	1219.22	1552.36	61162.984	6.2769	3.4028
39.5	124.09	1225.42	1560.25	61629.875	6.2849	3.4056
39.6	124.41	1231.63	1568.16	62099.136	6.2928	3.4085
39.7	124.72	1237.86	1576.09	62570.773	6.3008	3.4114
39.8	125.04	1244.10	1584.04	63044.792	6.3087	3.4142
39.9	125.35	1250.36	1592.01	63521.199	6.3166	3.4171
40.0	125.66	1256.64	1600.00	64000.000	6.3245	3.4200
40.1	125.98	1262.93	1608.01	64481.201	6.3325	3.4228
40.2	126.29	1269.23	1616.04	64964.808	6.3404	3.4256
40.3	126.61	1275.56	1624.09	65450.827	6.3482	3.4285
40.4	126.92	1281.90	1632.16	65939.264	6.3561	3.4313
40.5	127.23	1288.25	1640.25	66430.125	6.3639	3.4341
40.6	127.55	1294.62	1648.36	66923.416	6.3718	3.4370
40.7	127.86	1301.00	1656.49	67419.143	6.3796	3.4398
40.8	128.18	1307.41	1664.64	67911.312	6.3875	3.4426
40.9	128.49	1313.82	1672.81	68417.929	6.3953	3.4454
41.0	128.81	1320.25	1681.00	68921.000	6.4031	3.4482
41.1	129.12	1326.70	1689.21	69426.531	6.4109	3.4510
41.2	129.43	1333.17	1697.44	69934.528	6.4187	3.4538
41.3	129.75	1339.65	1705.69	70444.997	6.4265	3.4566
41.4	130.06	1346.14	1713.96	70957.944	6.4343	3.4594
41.5	130.38	1352.65	1722.25	71473.375	6.4421	3.4622
41.6	130.69	1359.18	1730.56	71991.296	6.4498	3.4650
41.7	131.00	1365.72	1738.89	72511.713	6.4575	3.4677
41.8	131.32	1372.28	1747.24	73034.632	6.4653	3.4705
41.9	131.63	1378.85	1755.61	73560.059	6.4730	3.4733
42.0	131.95	1385.44	1764.00	74088.000	6.4807	3.4760
42.1	132.26	1392.05	1772.41	74618.461	6.4884	3.4788
42.2	132.58	1398.67	1780.84	75151.448	6.4961	3.4815
42.3	132.89	1405.31	1789.29	75686.967	6.5038	3.4843
42.4	133.20	1411.96	1797.76	76225.024	6.5115	3.4870
42.5	133.52	1418.63	1806.25	76765.625	6.5192	3.4898
42.6	133.83	1425.31	1814.76	77308.776	6.5268	3.4925
42.7	134.15	1432.01	1823.29	77854.483	6.5345	3.4952
42.8	134.46	1438.72	1831.84	78402.752	6.5422	3.4980
42.9	134.77	1445.45	1840.41	78953.589	6.5498	3.5007

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
43.0	135.09	1452.20	1849.00	79507.000	6.5574	3.5034
43.1	135.40	1458.96	1857.61	80062.991	6.5651	3.5061
43.2	135.72	1465.74	1866.24	80621.568	6.5727	3.5088
43.3	136.03	1472.54	1874.89	81182.737	6.5803	3.5115
43.4	136.35	1479.34	1883.56	81746.504	6.5879	3.5142
43.5	136.66	1486.17	1892.25	82312.875	6.5954	3.5169
43.6	136.97	1493.01	1900.96	82881.856	6.6030	3.5196
43.7	137.29	1499.87	1909.69	83453.453	6.6106	3.5223
43.8	137.60	1506.74	1918.44	84027.672	6.6182	3.5250
43.9	137.92	1513.63	1927.21	84604.519	6.6257	3.5277
44.0	138.23	1520.53	1936.00	85184.000	6.6333	3.5303
44.1	138.54	1527.45	1944.81	85766.121	6.6408	3.5330
44.2	138.86	1534.39	1953.64	86350.888	6.6483	3.5357
44.3	139.17	1541.34	1962.49	86938.307	6.6558	3.5384
44.4	139.49	1548.30	1971.36	87528.384	6.6633	3.5410
44.5	139.80	1555.28	1980.25	88121.125	6.6708	3.5437
44.6	140.12	1562.28	1989.16	88716.536	6.6783	3.5463
44.7	140.43	1569.30	1998.09	89314.623	6.6858	3.5490
44.8	140.74	1576.33	2007.04	89915.392	6.6933	3.5516
44.9	141.06	1583.37	2016.01	90518.849	6.7007	3.5543
45.0	141.37	1590.43	2025.00	91125.000	6.7082	3.5569
45.1	141.69	1597.51	2034.01	91733.851	6.7156	3.5595
45.2	142.00	1604.60	2043.04	92345.408	6.7231	3.5621
45.3	142.31	1611.71	2052.09	92959.677	6.7305	3.5648
45.4	142.63	1618.83	2061.16	93576.664	6.7379	3.5674
45.5	142.94	1625.97	2070.25	94196.375	6.7454	3.5700
45.6	143.26	1633.13	2079.36	94818.816	6.7528	3.5726
45.7	143.57	1640.30	2088.49	95443.993	6.7602	3.5752
45.8	143.88	1647.48	2097.64	96071.912	6.7676	3.5778
45.9	144.20	1654.68	2106.81	96702.579	6.7749	3.5805
46.0	144.51	1661.90	2116.00	97336.000	6.7823	3.5830
46.1	144.83	1669.14	2125.21	97972.181	6.7897	3.5856
46.2	145.14	1676.39	2134.44	98611.128	6.7971	3.5882
46.3	145.46	1683.65	2143.69	99252.847	6.8044	3.5908
46.4	145.77	1690.93	2152.96	99897.344	6.8117	3.5934
46.5	146.08	1698.23	2162.25	100544.625	6.8191	3.5960
46.6	146.40	1705.54	2171.56	101194.696	6.8264	3.5986
46.7	146.71	1712.87	2180.89	101847.563	6.8337	3.6011
46.8	147.03	1720.21	2190.24	102503.232	6.8410	3.6037
46.9	147.34	1727.57	2199.61	103161.709	6.8484	3.6063
47.0	147.65	1734.94	2209.00	103823.000	6.8556	3.6088
47.1	147.97	1742.34	2218.41	104487.111	6.8629	3.6114
47.2	148.28	1749.74	2227.84	105154.048	6.8702	3.6139

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
47.3	148.60	1757.16	2237.29	105823.817	6.8775	3.6165
47.4	148.91	1764.60	2246.76	106496.424	6.8847	3.6190
47.5	149.23	1772.05	2256.25	107171.875	6.8920	3.6216
47.6	149.54	1779.52	2265.76	107850.176	6.8993	3.6241
47.7	149.85	1787.01	2275.29	108531.333	6.9065	3.6267
47.8	150.17	1794.51	2284.84	109215.352	6.9137	3.6292
47.9	150.48	1802.03	2294.41	109902.239	6.9209	3.6317
48.0	150.80	1809.56	2304.00	110592.000	6.9282	3.6342
48.1	151.11	1817.11	2313.61	111284.641	6.9354	3.6368
48.2	151.42	1824.67	2323.24	111980.168	6.9426	3.6393
48.3	151.74	1832.25	2332.89	112678.587	6.9498	3.6418
48.4	152.05	1839.84	2342.56	113379.904	6.9570	3.6443
48.5	152.37	1847.45	2352.25	114084.125	6.9642	3.6468
48.6	152.68	1855.08	2361.96	114791.256	6.9714	3.6493
48.7	153.00	1862.72	2371.69	115501.303	6.9785	3.6518
48.8	153.31	1870.38	2381.44	116214.272	6.9857	3.6543
48.9	153.62	1878.05	2391.21	116930.169	6.9928	3.6568
49.0	153.94	1885.74	2401.00	117649.000	7.0000	3.6593
49.1	154.25	1893.45	2410.81	118370.771	7.0071	3.6618
49.2	154.57	1901.17	2420.64	119095.488	7.0143	3.6643
49.3	154.88	1908.90	2430.49	119823.157	7.0214	3.6668
49.4	155.19	1916.65	2440.36	120553.784	7.0285	3.6692
49.5	155.51	1924.42	2450.25	121287.375	7.0356	3.6717
49.6	155.82	1932.21	2460.16	122023.936	7.0427	3.6742
49.7	156.14	1940.00	2470.09	122763.473	7.0498	3.6767
49.8	156.45	1947.82	2480.04	123505.992	7.0569	3.6791
49.9	156.77	1955.65	2490.01	124251.499	7.0640	3.6816
50.0	157.08	1963.50	2500.00	125000.000	7.0711	3.6840
51.0	160.22	2042.82	2601.00	132651.000	7.1414	3.7084
52.0	163.36	2123.72	2704.00	140608.000	7.2111	3.7325
53.0	166.50	2206.19	2809.00	148877.000	7.2801	3.7563
54.0	169.64	2290.22	2916.00	157464.000	7.3485	3.7798
55.0	172.78	2375.83	3025.00	166375.000	7.4162	3.8030
56.0	175 93	2463.01	3136.00	175616.000	7.4833	3.8259
57.0	179.07	2551.76	3249.00	185193.000	7.5498	3.8485
58.0	182.21	2642.08	3364.00	195112.000	7.6158	3.8709
59.0	185.35	2733.[illegible]7	3481.00	205379.000	7.6811	3.8930
60.0	188.49	2827.44	3600.00	216000.000	7.7460	3.9149
61.0	191.63	2922.47	3721.00	226981.000	7.8102	3.9365
62.0	194.77	3019.07	3844.00	238328.000	7.8740	3.9579
63.0	197.92	3117.25	3969.00	250047.000	7.9373	3.9791
64.0	201.06	3216.99	4096.00	262144.000	8.0000	4.0000
65.0	204.20	3318.31	4225.00	274625.000	8.0623	4.0207
66.0	207.34	3421.20	4356.00	287496.000	8.1240	4.0412

CONSTANTS—*Continued.*

n	$n\pi$	$n^2\frac{\pi}{4}$	n^2	n^3	$\sqrt{n}$	$\sqrt[3]{n}$
67.0	210.48	3525.66	4489.00	300763.000	8.1854	4.0615
68.0	213.63	3631.69	4624.00	314432.000	8.2462	4.0817
69.0	216.77	3739.29	4761.00	328509.000	8.3066	4.1016
70.0	219.91	3848.46	4900.00	343000.000	8.3666	4.1213
71.0	223.05	3959.20	5041.00	357911.000	8.4261	4.1408
72.0	226.19	4071.51	5184.00	373248.000	8.4853	4.1602
73.0	229.33	4185.39	5329.00	389017.000	8.5440	4.1793
74.0	232.47	4300.85	5476.00	405224.000	8.6023	4.1983
75.0	235.62	4417.87	5625.00	421875.000	8.6603	4.2172
76.0	238.76	4536.47	5776.00	438976.000	8.7178	4.2358
77.0	241.90	4656.63	5929.00	456533.000	8.7750	4.2543
78.0	245.04	4778.37	6084.00	474552.000	8.8318	4.2727
79.0	248.18	4901.68	6241.00	493039.000	8.8882	4.2908
80.0	251.32	5026.56	6400.00	512000.000	8.9443	4.3089
81.0	254.47	5153.01	6561.00	531441.000	9.0000	4.3267
82.0	257.61	5281.03	6724.00	551368.000	9.0554	4.3445
83.0	260.75	5410.62	6889.00	571787.000	9.1104	4.3621
84.0	263.89	5541.78	7056.00	592704.000	9.1652	4.3795
85.0	267.03	5674.50	7225.00	614125.000	9.2195	4.3968
86.0	270.17	5808.81	7396.00	636056.000	9.2736	4.4140
87.0	273.32	5944.69	7569.00	658503.000	9.3274	4.4310
88.0	276.46	6082.13	7744.00	681472.000	9.3808	4.4480
89.0	279.60	6221.13	7921.00	704969.000	9.4340	4.4647
90.0	282.74	6361.74	8100.00	729000.000	9.4868	4.4814
91.0	285.88	6503.89	8281.00	753571.000	9.5394	4.4979
92.0	289.02	6647.62	8464.00	778688.000	9.5917	4.5144
93.0	292.17	6792.92	8649.00	804357.000	9.6437	4.5307
94.0	295.31	6939.78	8836.00	830584.000	9.6954	4.5468
95.0	298.45	7088.23	9025.00	857375.000	9.7468	4.5629
96.0	301.59	7238.24	9216.00	884736.000	9.7980	4.5789
97.0	304.73	7389.83	9409.00	912673.000	9.8489	4.5947
98.0	307.87	7542.98	9604.00	941192.000	9.8995	4.6104
99.0	311.02	7697.68	9801.00	970299.000	9.9499	4.6261
100.0	314.16	7854.00	10000.00	1000000.000	10.0000	4.6416

II.

LOGARITHMS.

Hyperbolic Logarithms.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1.00	0.0000	2.30	0.8329	3.60	1.2809	4.90	1.5892	6.40	1.8563
1.05	0.0488	2.35	0.8544	3.65	1.2947	4.95	1.5994	6.50	1.8718
1.10	0.0953	2.40	0.8755	3.70	1.3083	5.00	1.6094	6.60	1.8871
1.15	0.1398	2.45	0.8961	3.75	1.3218	5.05	1.6194	6.70	1.9021
1.20	0.1823	2.50	0.9163	3.80	1.3350	5.10	1.6292	6.80	1.9169
1.25	0.2231	2.55	0.9361	3.85	1.3481	5.15	1.6390	6.90	1.9315
1.30	0.2624	2.60	0.9555	3.90	1.3610	5.20	1.6487	7.00	1.9459
1.35	0.3001	2.65	0.9746	3.95	1.3737	5.25	1.6582	7.20	1.9741
1.40	0.3365	2.70	0.9933	4.00	1.3863	5.30	1.6677	7.40	2.0015
1.45	0.3716	2.75	1.0116	4.05	1.3987	5.35	1.6771	7.60	2.0281
1.50	0.4055	2.80	1.0296	4.10	1.4110	5.40	1.6864	7.80	2.0541
1.55	0.4383	2.85	1.0473	4.15	1.4231	5.45	1.6956	8.00	2.0794
1.60	0.4700	2.90	1.0647	4.20	1.4351	5.50	1.7047	8.25	2.1102
1.65	0.5008	2.95	1.0818	4.25	1.4469	5.55	1.7138	8.50	2.1401
1.70	0.5306	3.00	1.0986	4.30	1.4586	5.60	1.7228	8.75	2.1691
1.75	0.5596	3.05	1.1154	4.35	1.4701	5.65	1.7317	9.00	2.1972
1.80	0.5878	3.10	1.1314	4.40	1.4816	5.70	1.7405	9.25	2.2246
1.85	0.6152	3.15	1.1474	4.45	1.4929	5.75	1.7492	9.50	2.2513
1.90	0.6419	3.20	1.1632	4.50	1.5041	5.80	1.7579	9.75	2.2773
1.95	0.6678	3.25	1.1787	4.55	1.5151	5.85	1.7664	10.00	2.3026
2.00	0.6931	3.30	1.1939	4.60	1.5261	5.90	1.7750	11.00	2.3979
2.05	0.7178	3.35	1.2090	4.65	1.5369	5.95	1.7834	12.00	2.4849
2.10	0.7419	3.40	1.2238	4.70	1.5476	6.00	1.7918	13.00	2.5649
2.15	0.7655	3.45	1.2384	4.75	1.5581	6.10	1.8083	14.00	2.6391
2.20	0.7885	3.50	1.2528	4.80	1.5686	6.20	1.8245	15.00	2.7081
2.25	0.8109	3.55	1.2669	4.85	1.5790	6.30	1.8405	16.00	2.7726

Common Logarithms: 10–1200.

N.	0	1	2	3	4	5	6	7	8	9	Diff.
10	00000	00432	00860	01284	01703	02119	02531	02938	03342	03743	396
11	04139	04532	04922	05308	05690	06070	06446	06819	07188	07555	363
12	07918	08279	08636	08991	09342	09691	10037	10380	10721	11059	335
13	11394	11727	12057	12385	12710	13033	13354	13672	13988	14301	312
14	14613	14922	15229	15534	15836	16137	16435	16732	17026	17319	290
15	17609	17898	18184	18469	18752	19033	19312	19590	19866	20140	272
16	20412	20683	20952	21219	21484	21748	22011	22272	22531	22789	256
17	23045	23300	23553	23805	24055	24304	24551	24797	25042	25285	242
18	25527	25768	26007	26245	26482	26717	26951	27184	27416	27646	229
19	27875	28103	28330	28556	28780	29003	29226	29447	29667	29885	218
20	30103	30320	30535	30750	30963	31175	31387	31597	31806	32015	207
21	32222	32428	32634	32838	33041	33244	33445	33646	33846	34044	198
22	34242	34439	34635	34830	35025	35218	35411	35603	35793	35984	189
23	36173	36361	36549	36736	36922	37107	37291	37475	37658	37840	181
24	38021	38202	38382	38561	38739	38917	39094	39270	39445	39620	174
25	39794	39967	40140	40312	40483	40654	40824	40993	41162	41330	167
26	41497	41664	41830	41996	42160	42325	42488	42651	42813	42975	161
27	43136	43297	43457	43616	43775	43933	44091	44248	44404	44560	156
28	44716	44871	45025	45179	45332	45484	45637	45788	45939	46090	150
29	46240	46389	46538	46687	46835	46982	47129	47276	47422	47567	145

COMMON LOGARITHMS—*Continued.*

N.	0	1	2	3	4	5	6	7	8	9	Diff.
30	47712	47857	48001	48144	48287	48430	48572	48714	48855	48996	140
31	49136	49276	49415	49554	49693	49831	49969	50106	50243	50379	136
32	50515	50651	50786	50920	51055	51188	51322	51455	51587	51720	132
33	51851	51983	52114	52244	52375	52504	52634	52763	52892	53020	128
34	53148	53275	53403	53529	53656	53782	53908	54033	54158	54283	124
35	54407	54531	54654	54777	54900	55023	55145	55267	55388	55509	121
36	55630	55751	55871	55991	56110	56229	56348	56467	56585	56703	117
37	56820	56937	57054	57171	57287	57403	57519	57634	57749	57864	114
38	57978	58092	58206	58320	58433	58546	58659	58771	58883	58995	111
39	59106	59218	59329	59439	59550	59660	59770	59879	59988	60097	109
40	60206	60314	60423	60531	60638	60746	60853	60959	61066	61172	106
41	61278	61384	61490	61595	61700	61805	61909	62014	62118	62221	104
42	62325	62428	62531	62634	62737	62839	62941	63043	63144	63246	101
43	63347	63448	63548	63649	63749	63849	63949	64048	64147	64246	99
44	64345	64444	64542	64640	64738	64836	64933	65031	65128	65225	97
45	65321	65418	65514	65610	65706	65801	65896	65992	66087	66181	95
46	66276	66370	66464	66558	66652	66745	66839	66932	67025	67117	93
47	67210	67302	67394	67486	67578	67669	67761	67852	67943	68034	90
48	68124	68215	68305	68395	68485	68574	68664	68753	68842	68931	89
49	69020	69108	69197	69285	69373	69461	69548	69636	69723	69810	87
50	69897	69984	70070	70157	70243	70329	70415	70501	70586	70672	86
51	70757	70842	70927	71012	71096	71181	71265	71349	71433	71517	84
52	71600	71684	71767	71850	71933	72016	72099	72181	72263	72346	83
53	72428	72509	72591	72673	72754	72835	72916	72997	73078	73159	81
54	73239	73320	73400	73480	73560	73640	73719	73799	73878	73957	80
55	74036	74115	74194	74273	74351	74429	74507	74586	74663	74741	78
56	74819	74896	74974	75051	75128	75205	75282	75358	75435	75511	77
57	75587	75664	75740	75815	75891	75967	76042	76118	76193	76268	76
58	76343	76418	76492	76567	76641	76716	76790	76864	76938	77012	74
59	77085	77159	77232	77305	77379	77452	77525	77597	77670	77743	73
60	77815	77887	77960	78032	78104	78176	78247	78319	78390	78462	72
61	78533	78604	78675	78746	78817	78888	78958	79029	79099	79169	71
62	79239	79309	79379	79449	79518	79588	79657	79727	79796	79865	69
63	79934	80003	80072	80140	80209	80277	80346	80414	80482	80550	68
64	80618	80686	80754	80821	80889	80956	81023	81090	81158	81224	67
65	81291	81358	81425	81491	81558	81624	81690	81757	81823	81889	66
66	81954	82020	82086	82151	82217	82282	82347	82413	82478	82543	65
67	82607	82672	82737	82802	82866	82930	82995	83059	83123	83187	64
68	83251	83315	83378	83442	83506	83569	83632	83696	83759	83822	63
69	83885	83948	84011	84073	84136	84198	84261	84323	84386	84448	63
70	84510	84572	84634	84696	84757	84819	84880	84942	85003	85065	62
71	85126	85187	85248	85309	85370	85431	85491	85552	85612	85673	61
72	85733	85794	85854	85914	85974	86034	86094	86153	86213	86273	60
73	86332	86392	86451	86510	86570	86629	86688	86747	86806	86864	59
74	86923	86982	87040	87099	87157	87216	87274	87332	87390	87448	58
75	87506	87564	87622	87679	87737	87795	87852	87910	87967	88024	58
76	88081	88138	88195	88252	88309	88366	88423	88480	88536	88593	57
77	88649	88705	88762	88818	88874	88930	88986	89042	89098	89154	56
78	89209	89265	89321	89376	89432	89487	89542	89597	89653	89708	55
79	89763	89818	89873	89927	89982	90037	90091	90146	90200	90255	55
80	90309	90363	90417	90472	90526	90580	90634	90687	90741	90795	54
81	90849	90902	90956	91009	91062	91116	91169	91222	91275	91328	53
82	91381	91434	91487	91540	91593	91645	91698	91751	91803	91855	52
83	91908	91960	92012	92065	92117	92169	92221	92273	92324	92376	52
84	92428	92480	92531	92583	92634	92686	92737	92788	92840	92891	51
85	92942	92993	93044	93095	93146	93197	93247	93298	93349	93399	51
86	93450	93500	93551	93601	93651	93702	93752	93802	93852	93902	50
87	93952	94002	94052	94101	94151	94201	94250	94300	94349	94399	50

COMMON LOGARITHMS—*Continued.*

N.	0	1	2	3	4	5	6	7	8	9	Diff.
88	94448	94498	94547	94596	94645	94694	94743	94792	94841	94890	49
89	94939	94988	95036	95085	95134	95182	95231	95279	95328	95376	49
90	95424	95472	95521	95569	95617	95665	95713	95761	95809	95856	48
91	95904	95952	95999	96047	96095	96142	96190	96237	96284	96332	47
92	96379	96426	96473	96520	96567	96614	96661	96708	96755	96802	47
93	96848	96895	96942	96988	97035	97081	97128	97174	97220	97267	46
94	97313	97359	97405	97451	97497	97543	97589	97635	97681	97727	46
95	97772	97818	97864	97909	97955	98000	98046	98091	98137	98182	45
96	98227	98272	98318	98363	98408	98453	98498	98543	98588	98632	45
97	98677	98722	98767	98811	98856	98900	98945	98989	99034	99078	45
98	99123	99167	99211	99255	99300	99344	99388	99432	99476	99520	44
99	99564	99607	99651	99695	99739	99782	99826	99870	99913	99957	44
100	00000	00043	00087	00130	00173	00217	00260	00303	00346	00389	43
101	00432	00475	00518	00561	00604	00647	00689	00732	00775	00817	43
102	00860	00903	00945	00988	01030	01072	01115	01157	01199	01242	42
103	01284	01326	01368	01410	01452	01494	01536	01578	01620	01662	42
104	01703	01745	01787	01828	01870	01912	01953	01995	02036	02078	42
105	02119	02160	02202	02243	02284	02325	02366	02407	02449	02490	41
106	02531	02572	02612	02653	02694	02735	02776	02816	02857	02898	41
107	02938	02979	03019	03060	03100	03141	03181	03222	03262	03302	41
108	03342	03383	03423	03463	03503	03543	03583	03623	03663	03703	40
109	03743	03782	03822	03862	03902	03941	03981	04021	04060	04100	40
110	04139	04179	04218	04258	04297	04336	04376	04415	04454	04493	39
111	04532	04571	04610	04650	04689	04727	04766	04805	04844	04883	39
112	04922	04961	04999	05038	05077	05115	05154	05192	05231	05269	39
113	05308	05346	05385	05423	05461	05500	05538	05576	95614	05652	38
114	05690	05729	05767	05805	05843	05881	05918	05956	05994	06032	38
115	06070	06108	06145	06183	06221	06258	06296	06333	06371	06408	38
116	06446	06483	06521	06558	06595	06633	06670	06707	06744	06781	37
117	06819	06856	06893	06930	06967	07004	07041	07078	07115	07151	37
118	07188	07225	07262	07298	07335	07372	07408	07445	07482	07518	37
119	07555	07591	07628	07664	07700	07773	07773	07809	07846	07882	36

		Log.
Base of Naperian logarithms, ...	$\epsilon = 2.7182818$	0.4342945
Log. ϵ = Modulus of common logarithms, ...	$M = 0.4342945$	9.6377843 − 10.

III.

MEAN PRESSURES FOR VARIOUS METHODS OF EXPANSION.

Values of $\frac{p_m}{p_1}$. Adiabatic Expansion of Steam.

Ratio of Expansion.	Cut-off, $\frac{1}{r}$.	Percentage of Steam and Value of n.							
		100	90	80	76	70	60	50	100
		1.135	1.125	1.115	1.111	1.105	1.095	1.085	1.333
2	$\frac{1}{2}$	.829	.831	.833	.834	.835	.836	.837	.810
$2\frac{1}{4}$	$\frac{4}{9}$	.785	.787	.788	.789	.790	.791	.793	.754
$2\frac{1}{2}$	$\frac{2}{5}$	.744	.746	.747	.748	.749	.750	.751	.714
$2\frac{3}{4}$	$\frac{4}{11}$	.707	.708	.710	.711	.712	.713	.714	.675
3	$\frac{1}{3}$	.675	.676	.677	.678	.679	.681	.683	.639
$3\frac{1}{4}$	$\frac{4}{13}$	.644	.645	.647	.648	.649	.650	.652	.606
$3\frac{1}{3}$	$\frac{3}{10}$	.633	.635	.636	.637	.639	.641	.643	.600
$3\frac{1}{2}$	$\frac{2}{7}$	.616	.618	.619	.620	.622	.624	.626	.576
$3\frac{3}{4}$	$\frac{4}{15}$	.591	.592	.593	.594	.595	.596	.598	.552
4	$\frac{1}{4}$	.567	.568	.570	.572	.573	.574	.576	.523
$4\frac{1}{2}$	$\frac{2}{9}$	.525	.527	.528	.530	.531	.533	.534	.486
5	$\frac{1}{5}$	.488	.491	.493	.494	.496	.498	.500	.447
$5\frac{1}{2}$	$\frac{2}{11}$	.458	.460	.462	.463	.465	.467	.470	.417
6	$\frac{1}{6}$	.432	.434	.435	.437	.439	.441	.443	.390
$6\frac{1}{2}$	$\frac{2}{13}$	.409	.410	.411	.413	.415	.417	.420	.369
7	$\frac{1}{7}$	.387	.390	.392	.394	.400	.403	.405	.345
8	$\frac{1}{8}$	.355	.356	.357	.358	.360	.361	.363	.312
10	$\frac{1}{10}$	.298	.300	.302	.303	.304	.305	.308	.263
20	$\frac{1}{20}$	.170	.173	.175	.177	.178	.180	.182	.144
50	$\frac{1}{50}$	.080	.082	.083	.084	.084	.085	.086	.063
100	$\frac{1}{100}$	.044	.045	.045	.046	.046	.047	048	.034

III.—(*Continued.*)

MEAN PRESSURES FOR VARIOUS METHODS OF EXPANSION.

Values of $\frac{p_m}{p_1}$ for Steam, Air, Gas, and Mixtures.

Ratio of Expansion, r.	Point of cut-off, $\frac{1}{r}$.	Steam Expanding, Dry and Saturated, n, 1.046.	Moist Air in Compressors, n, 1.20.	Steam and Leakage, Actual Engines.		Gas and Vapor in Gas-engine, n, 1.60.	Gases.	
				n, 0.50.	n, 0.75.		Isothermal, n, 1.00.	Adiabatic, n, 1.41.
2	$\frac{1}{2}$	.841	.825	.914	.875	.783	.846	.801
$2\frac{1}{4}$	$\frac{4}{9}$	.793	.787	.888	.844	.733	.804	.753
$2\frac{1}{2}$	$\frac{2}{5}$	.760	.745	.866	.800	.683	.765	.707
$2\frac{3}{4}$	$\frac{4}{11}$	.717	.700	.846	.785	.638	.731	.668
3	$\frac{1}{3}$	.695	.665	.824	.752	.598	.699	.638
$3\frac{1}{4}$	$\frac{4}{13}$	.665	.635	.802	.732	.578	.670	.596
$3\frac{1}{3}$	$\frac{3}{10}$	.652	.625	.796	.716	.568	.661	.588
$3\frac{1}{2}$	$\frac{2}{7}$	.632	.605	.782	.704	.548	.642	.568
$3\frac{3}{4}$	$\frac{4}{15}$	.608	.580	.775	.684	.515	.616	.538
4	$\frac{1}{4}$	.587	.550	.750	.664	.486	.566	.518
$4\frac{1}{2}$	$\frac{2}{9}$	.540	.510	.720	.624	.441	.555	.473
5	$\frac{1}{5}$	.510	.482	.695	.600	.406	.522	.428
$5\frac{1}{2}$	$\frac{2}{11}$	.478	.455	.674	.560	.371	.492	.406
6	$\frac{1}{6}$	.454	.420	.650	.530	.349	.465	.378
$6\frac{1}{2}$	$\frac{2}{13}$	.430	.390	.632	.515	.326	.441	.358
7	$\frac{1}{7}$	.409	.375	.612	.500	.303	.421	.337
8	$\frac{1}{8}$	.372	.340	.697	.468	.276	.385	.302
10	$\frac{1}{10}$	.326	.284	.532	.412	.225	.330	253
20	$\frac{1}{20}$	.192	.165	.396	.272	.103	.200	.138
50	$\frac{1}{50}$	.091	.074	.245	.193	.050	.098	.060
100	$\frac{1}{100}$	.053	.040	.180	.134	.025	.056	.032

III.—(*Continued.*)

MEAN PRESSURE RATIOS.

r	A	B	C	r	A	B	C	r	A	B	C	r	A	B	C
1.0	1.000	1.000	1.000	5.3	.478	.503	.488	9.6	.312	.340	.324	17.8	.194	.218	.204
1.1	0.996	0.996	0.996	5.4	.472	.497	.482	9.7	.310	.338	.322	18.0	.192	.216	.202
1.2	0.983	0.983	0.983	5.5	.467	.492	.477	9.8	.307	.335	.319	18.2	.190	.215	.200
1.3	.966	.968	.967	5.6	.461	.486	.471	9.9	.305	.333	.317	18.4	.189	.214	.199
1.4	.947	.952	.950	5.7	.456	.481	.466	10.0	.303	.330	.314	18.6	.187	.212	.197
1.5	.928	.934	.931	5.8	.450	.475	.460	10.2	.299	.325	.310	18.8	.185	.210	195
1.6	.910	.919	.914	5.9	.445	.470	.455	10.4	.295	.321	.306	19.0	.183	.208	.193
1.7	.890	.900	.895	6.0	.440	.465	.450	10.6	.291	.317	.302	19.2	.182	.207	.192
1.8	.870	.880	.875	6.1	.434	.460	.445	10.8	.287	.313	.298	19.4	.180	.205	.190
1.9	.850	.862	.856	6.2	.429	.455	.440	11.0	.283	.309	.294	19.6	.179	.204	.189
2.0	.833	.846	.840	6.3	.424	.450	.435	11.2	.279	.305	.290	19.8	.178	.202	.187
2.1	.817	.830	.824	6.4	.419	.445	.430	11.4	.275	.301	.286	20.0	.177	.200	.186
2.2	.798	.812	.805	6.5	.414	.441	.426	11.6	.272	.298	.283	20.2	.175	.198	.184
2.3	.780	.795	.787	6.6	.409	.436	.421	11.8	.268	.294	.279	20.4	.174	.196	.183
2.4	.763	.780	.771	6.7	.405	.432	.417	12.0	.264	.290	.275	20.6	.173	.194	.182
2.5	.748	.766	.756	6.8	.401	.428	.413	12.2	.261	.287	.272	20.8	.171	.193	.180
2.6	.732	.750	.740	6.9	.396	.424	.408	12.4	.257	.283	.268	21.0	.169	.192	.178
2.7	.718	.736	.726	7.0	.393	.421	.405	12.6	.254	.280	.265	21.2	.168	.191	.177
2.8	.705	.723	.713	7.1	.389	.417	.401	12.8	.251	.277	.262	21.4	.167	.190	.176
2.9	.692	.710	.700	7.2	.385	.413	.397	13.0	.248	.274	.259	21.6	.165	.188	.174
3.0	.680	.699	.688	7.3	.381	.410	.393	13.2	.245	.271	.256	21.8	.164	.187	.173
3.1	.668	.687	.676	7.4	.377	.406	.390	13.4	.242	.268	.253	22.0	.163	.186	.172
3.2	.656	.675	.664	7.5	.373	.402	.386	13.6	.239	.265	.250	22.2	.162	.185	.171
3.3	.645	.664	.653	7.6	.370	.399	.383	13.8	.236	.262	.247	22.4	.161	.184	.170
3.4	.634	.653	.642	7.7	.367	.396	.380	14.0	.234	.260	.245	22.6	.160	.183	.169
3.5	.622	.642	.631	7.8	.363	.392	.376	14.2	.231	.257	.242	22.8	.159	.182	.168
3.6	.612	.632	.621	7.9	.360	.389	.373	14.4	.228	.254	.239	23.0	.158	.180	.167
3.7	.602	.622	.611	8.0	.356	.385	.370	14.6	.225	.251	.236	23.2	.156	.179	.165
3.8	.593	.613	.602	8.1	.353	.382	.367	14.8	.223	.249	.234	23.4	.155	.178	.164
3.9	.584	.604	.593	8.2	.350	.379	.364	15.0	.221	.247	.232	23.6	.154	.177	.163
4.0	.572	.596	.583	8.3	.347	.376	.361	15.2	.219	.245	.230	23.8	.153	.176	.162
4.1	.565	.587	.575	8.4	.344	.373	.358	15.4	.217	.242	.227	24.0	.151	.174	.160
4.2	.556	.578	.566	8.5	.341	.371	.355	15.6	.215	.240	.225	24.2	.150	.173	.159
4.3	.548	.570	.558	8.6	.338	.368	.352	15.8	.213	.238	.223	24.4	.149	.172	.158
4.4	.540	.563	.550	8.7	.335	.364	.349	16.0	.211	.236	.221	24.6	.148	.171	.157
4.5	.532	.555	.542	8.8	.332	.361	.346	16.2	.209	.234	.219	24.8	.147	.170	.156
4.6	.525	.548	.535	8.9	.330	.358	.34	16.4	.207	.232	.217	25.0	.146	.169	.155
4.7	.518	.542	.528	9.0	.327	.355	.340	16.6	.205	.230	.215				
4.8	.511	.535	.521	9.1	.324	.353	.337	16.8	.203	.228	.213				
4.9	.504	.528	.514	9.2	.322	.351	.335	17 0	.201	.226	.211				
5.0	.496	.522	.506	9.3	.320	.348	.332	17.2	.199	.224	.209				
5.1	.490	.515	.500	9.4	.317	.345	.329	17.4	.197	.222	.207				
5.2	.484	.509	.494	9.5	.315	.343	.327	17.6	.195	.220	.205				

Column r, the ratio of expansion $= \frac{v_2}{v_1}$

" A, ratio of mean to initial pressure, $\frac{p_m}{p_1} = \frac{10 - 9r^{-\frac{1}{9}}}{r}$ { For dry steam, expanded without gain or loss of heat, in a non-conducting cylinder.

" B, " " " " $\frac{p_m}{p_1} = \frac{1 + \text{hyp. log. } r}{r}$ { For damp steam, expanded receiving heat.

" C, " " " " $\frac{p_m}{p_1} = \frac{17 - 16r^{-\frac{1}{16}}}{r}$ { For dry steam, expanded receiving heat sufficient to prevent liquefaction.

RULE.—To find the mean pressure exerted throughout the stroke, multiply the initial pressure by the number opposite the ratio of expansion, in the column corresponding with the conditions of expansion. (From Northcott.)

IV.

TERMINAL PRESSURE RATIOS $\frac{p_1}{p_2}$

r	A	B	C	r	A	B	C	r	A	B	C	r	A	B	C
1.0	0.00	0.0	0.00	4.7	5.58	4.7	5.18	8.3	10.5	8.3	9.47	13.8	18.5	13.8	16.2
1.1	1.11	1.1	1.11	4.8	5.70	4.8	5.29	8.4	10.6	8.4	9.59	14.0	18.8	14.0	16.5
1.2	1.22	1.2	1.21	4.9	5.84	4.9	5.41	8.5	10.7	8.5	9.64	14.2	19.1	14.2	16.8
1.3	1.34	1.3	1.32	5.0	5.98	5.0	5.52	8.6	10.9	8.6	9.76	14.4	19.4	14.4	17.0
1.4	1.45	1.4	1.43	5.1	6.11	5.1	5.64	8.7	11.0	8.7	9.88	14.6	19.7	14.6	17.2
1.5	1.57	1.5	1.54	5.2	6.24	5.2	5.76	8.8	11.2	8.8	10.0	14.8	20.0	14.8	17.5
1.6	1.69	1.6	1.65	5.3	6.38	5.3	5.88	8.9	11.3	8.9	10.2	15.0	20.3	15.0	17.8
1.7	1.80	1.7	1.75	5.4	6.51	5.4	6.00	9.0	11.5	9.0	10.3	15.2	20.6	15.2	18.0
1.8	1.92	1.8	1.87	5.5	6.64	5.5	6.12	9.1	11.6	9.1	10.4	15.4	20.9	15.4	18.2
1.9	2.04	1.9	1.98	5.6	6.78	5.6	6.23	9.2	11.8	9.2	10.6	15.6	21.2	15.6	18.5
2.0	2.16	2.0	2.08	5.7	6.91	5.7	6.35	9.3	11.9	9.3	10.7	15.8	21.5	15.8	18.7
2.1	2.28	2.1	2.20	5.8	7.05	5.8	6.47	9.4	12.0	9.4	10.8	16.0	21.8	16.0	19.0
2.2	2.40	2.2	2.31	5.9	7.18	5.9	6.59	9.5	12.2	9.5	10.9	16.2	22.1	16.2	19.3
2.3	2.52	2.3	2.42	6.0	7.32	6.0	6.71	9.6	12.3	9.6	11.0	16.4	22.4	16.4	19.5
2.4	2.64	2.4	2.53	6.1	7.45	6.1	6.83	9.7	12.5	9.7	11.1	16.6	22 7	16.6	19.8
2.5	2.76	2.5	2.64	6.2	7.59	6.2	6.95	9.8	12.6	9.8	11.3	16.8	23.0	14.8	20.0
2.6	2.89	2.6	2.76	6.3	7.73	6.3	7.07	9.9	12.8	9.9	11.4	17.0	23.3	17.0	20.3
2.7	3.01	2.7	2.87	6.4	7.86	6.4	7.18	10.0	12.9	10.0	11.5	17.2	23.6	17.2	20.5
2.8	3.14	2.8	2.99	6.5	8.00	6.5	7.30	10.2	13.2	10.2	11.7	17.4	23.9	17.4	20.8
2.9	3.26	2.9	3.10	6.6	8.14	6.6	7.42	10.4	13.5	10.4	12.0	17.6	24.2	17.6	21.0
3.0	3.39	3.0	3.21	6.7	8.27	6.7	7.54	10.6	13.8	10.6	12.3	17.8	24.5	17.8	21.3
3.1	3.51	3.1	3.32	6.8	8.41	6.8	7.66	10.8	14.1	10.8	12.5	18.0	24.8	18.0	21.6
3.2	3.64	3.2	3.43	6.9	8.55	6.9	7.78	11.0	14.3	11.0	12.8	18.2	25.1	18.2	21.8
3.3	3.77	3.3	3.55	7.0	8.69	7.0	7.90	11.2	14.6	11.2	13.0	18.4	25.4	18.4	22.0
3.4	3.89	3.4	3.67	7.1	8.83	7.1	8.02	11.4	14.9	11.4	13.3	18.6	25.7	18.6	22.3
3.5	4.02	3.5	3.79	7.2	8.96	7.2	8.14	11.6	15.2	11.6	13.5	18.8	26.[illegible]	18.8	22.5
3.6	4.15	3.6	3.90	7.3	9.10	7.3	8.27	11.8	15.5	11.8	13.7	19.0	26.3	19.0	22.8
3.7	4.28	3.7	4.01	7.4	9.24	7.4	8.38	12.0	15.8	12.0	14.0	19.2	26.6	19.2	23.1
3.8	4.41	3.8	4.13	7.5	9.38	7.5	8.49	12.2	16.1	12.2	14.2	19.4	26.9	19.4	23.3
3.9	4.54	3.9	4.25	7.6	9.52	7.6	8.62	12.4	16.4	12.4	14.5	19.6	27.2	19.6	23.6
4.0	4.66	4.0	4.36	7.7	9.66	7.7	8.74	12.6	16.7	12.6	14.8	19.8	27.5	19.8	23.9
4.1	4.79	4.1	4.47	7.8	9.80	7.8	8.87	12.8	17.0	12.8	15.0	20.0	27.9	20.0	24.1
4.2	4.91	4.2	4.60	7.9	9.94	7.9	8.99	13.0	17.3	13.0	15.2	21.0	29.5	21.0	25.4
4.3	5.05	4.3	4.71	8.0	10.1	8.0	9.11	13.2	17.6	13.2	15.5	22.0	31.0	22.0	26.7
4.4	5.18	4.4	4.82	8.1	10.2	8.1	9.23	13.4	17.9	13.4	15.7	23.0	32.6	23.0	28.0
4.5	5.32	4.5	4.95	8.2	10.3	8.2	9.35	13.6	18.2	13.6	16.0	24.0	34.1	24.0	29.3
4.6	5.45	4.6	5.06												

Column r, ratio of expansion $= \frac{v_2}{v_1}$

" A, ratio of initial to final pressure, $p_2 = \frac{p_1}{r^{\frac{10}{9}}}$ .. { For dry steam, expanded without gain or loss of heat in a non-conducting cylinder.

" B, " " " " $p_2 = \frac{p_1}{r}$ .. { For damp steam, expanded receiving heat.

" C, " " " " $p_2 = \frac{p_1}{r^{\frac{17}{16}}}$ .. { For dry steam, expanded receiving sufficient heat to prevent liquefaction.

RULE.—To find the final pressure obtaining with any ratio of expansion, divide the initial pressure by the number opposite the ratio of expansion, in the column corresponding with the conditions of expansion.

V.

WORKING OF STEAM.—(NORTHCOTT.)

HEAT-TRANSFER AND TRANSFORMATION.

Initial absolute pressure per sq. in.	Ratio of Expansion.	Mean total pressure.	Mean Effective Pressure.	Mean Back Pressure.	Pressure at Release.	Indicated Work per lb. of Steam.	Steam per Indicated Horse-power per Hour.	Piston Displacement per lb. of Steam.	Piston Displacement per Indicated Horse-power per Hour.	Piston Area per Indicated Horse-power with speed of 330 ft. per minute.	Heat entering Cylinder per lb. of Steam.	Heat imparted during Expansion per lb. of Steam.	Heat expended per lb. of Steam.	Heat converted into Motive Power indicated per lb. of Steam.	Heat carried off with the Exhaust Steam per lb.	Heat expended per Indicated Horse-power per Hour.	Efficiency of Steam.	Coal per Indicated Horse-power per Hour with Boiler of .71 efficiency.
p_1.	r.	p_m.	p_e.	p_3.	p_2.	Ft. lbs.	Lbs.	Cu. ft.	Cu. ft.	Sq. in.	Units.	Units.	Units.	Units.	Units.	Units.	E.	Lbs.
Class 1											From 212° F.		From 212° F.		From 212° F.	From 212° F.		
60	1	60	44	16	60	44,660	44.4	7.0500	313.0	2.27	991	0	991	57.8	933.2	44,001	.0582	4.40
80	1	80	64	16	80	49,698	39.9	5.3926	215.0	1.56	997	0	997	64.4	932.6	39,781	.0644	3.98
100	1	100	84	16	100	52,952	37.4	4.3777	163.7	1.19	1,002	0	1,002	68.6	933.4	37,475	.0684	3.75
120	1	120	104	16	120	55,234	35.8	2.6887	132.0	0.96	1,006	0	1,006	71.5	934.5	36,015	.0712	3.61
150	1	150	134	16	150	57,673	34.4	2.9888	102.8	0.75	1,011	0	1,011	74.7	936.3	34,779	.0737	3.48
200	1	200	184	16	200	60,475	32.7	2.2834	74.6	0.54	1,018	0	1,018	78.3	939.7	33,289	.0770	3.33
250	1	250	234	16	250	62,454	31.7	1.8533	58.7	0.43	1,024	0	1,024	80.9	943.1	32,461	.0790	3.25
300	1	300	284	16	300	64,016	30.9	1.5653	48.3	0.35	1,029	0	1,029	82.9	946.1	31,797	.0806	3.18
Class 2											From 212° F.		From 212° F.		From 212° F.	From 212° F.		
60	2	50.7	34.7	16	30	70,445	29.5	14.1000	396.2	2.89	991	0	991	91.3	899.7	29,227	.0877	2.93
80	2	67.6	51.6	16	40	80,139	25.9	10.7852	266.4	1.94	997	0	997	103.8	893.2	25,823	.0993	2.59
100	2	84.6	68.6	16	50	86,490	24.0	8.7554	200.5	1.46	1,002	0	1,002	112.0	890.0	24,049	.1066	2.41
120	2	101.5	85.5	16	60	90,840	22.9	7.3774	160.8	1.17	1,006	0	1,006	117.6	888.4	23,038	.1113	2.31
150	2	126.9	110.9	16	75	95,442	21.8	5.9776	124.3	0.90	1,011	0	1,011	123.6	887.4	22,040	.1118	2.21
200	2	169.2	153.2	16	100	100,603	20.7	4.5648	89.9	0.65	1,018	0	1,018	130.3	887.7	21,073	.1217	2.11
250	2	211.5	195.5	16	125	104,406	19.9	3.7066	70.4	0.51	1,024	0	1,024	135.2	888.8	20,478	.1252	2.05
300	2	253.8	237.8	16	150	107,202	19.4	3.1306	57.9	0.42	1,029	0	1,029	138.8	890.2	19,963	.1280	1.99

Class 3											From 212° F.		From 212° F.		From 212° F.	From 212° F.		
60	3.4	38.0	22.0	16	16	77,200	25.7	24.32	625.0	4.54	991	77	1,068	100	968	27,448	.0934	2.75
80	4.5	43.1	27.1	16	16	94,956	20.9	24.32	508.3	3.69	997	94	1,091	123	968	22,802	.1120	2.28
100	5.5	47.1	31.1	16	16	108,852	18.2	24.32	441.6	3.21	1,002	107	1,109	141	968	20,184	.1270	2.02
120	6.6	50.6	34.6	16	16	121,204	16.3	24.32	396.4	2.89	1,006	119	1,125	157	968	18,338	.1398	1.84
150	8.1	54.1	38.1	16	16	133,556	14.8	24.32	359.9	2.61	1,011	130	1,141	173	968	16,887	.1518	1.69
250	10.6	59.6	43.6	16	16	152,856	12.9	24.32	313.7	2.28	1,018	148	1,166	198	968	15,042	.1705	1.51
200	13.1	65.8	47.8	16	16	167,524	11.8	24.32	287.0	2.08	1,024	161	1,185	217	968	13,984	.1834	1.40
300	15.5	67.1	51.1	16	16	179,104	11.0	24.32	267.5	1.94	1,029	171	1,200	232	968	13,200	.1943	1.32
Class 4											From 102° F.		From 102° F.		From 102° F.	From 102° F.		
60	3.4	38.0	35.0	3	16	122,826	16.1	24.32	391.5	2.84	1,101	77	1,178	159.0	1,019	18,966	.1352	1.90
80	4.5	43.1	40.1	3	16	140,582	14.0	24.32	330.4	2.40	1,107	94	1,201	182.0	1,019	16,815	.1465	1.69
100	5.5	47.1	44.1	3	16	154,478	12.8	24.32	311.2	2.26	1,112	107	1,219	200.0	1,019	15,604	.1624	1.57
120	6.6	50.6	47.6	3	16	166,830	11.8	24.32	286.9	2.08	1,116	119	1,235	216.0	1,019	14,573	.1759	1.46
150	8.1	54.1	51.1	3	16	179,182	11.0	24.32	267.5	1.94	1,121	130	1,251	232.0	1,019	13,761	.1856	1.38
200	10.7	59.6	56.6	3	16	198,482	9 9	24.32	240.7	1.75	1,128	148	1,276	257.0	1,019	12,633	.2002	1.27
250	13.1	65.8	62.8	3	16	213,150	9.2	24.32	223.7	1.62	1,134	161	1,295	276.0	1,019	11,914	.2152	1.20
300	15.5	67.1	64.1	3	16	224,730	8.8	24.32	214.0	1.55	1,139	171	1,310	291.0	1,019	11,528	.2138	1.16
Classes 5 & 6											From 102° F.		From 102° F.		From 102° F.	From 102° F.		
60	16.7	12.8	9.8	3	3	166,752	11.9	118	1,404	10.2	1,101	170	1,271	216	1,055	15,125	.1695	1.52
80	23.7	13.8	10.8	3	3	184,508	10.7	118	1,262	9.2	1,107	184	1,294	239	1,055	13,846	.1852	1.39
100	26.9	14.7	11.7	3	3	198,404	10.0	118	1,180	8.5	1,112	200	1,312	257	1,055	13,120	.1954	1.32
120	32.0	15.4	12.4	3	3	210,756	9.4	118	1,109	8.0	1,116	212	1,328	273	1,055	12,484	.2052	1.25
150	39.5	16.2	13.2	3	3	223,108	8.9	118	1,050	7.6	1,121	223	1,344	289	1,055	11,962	.2144	1.20
200	51.7	17.3	14.3	3	3	242,408	8.2	118	968	7.0	1,128	241	1,369	314	1,055	11,226	.2284	1.13
250	63.6	18.2	15.2	3	3	257,076	7.7	118	900	6.6	1,134	254	1,388	333	1,055	10,688	.2399	1.07
300	75.3	18.8	15.8	3	3	268,656	7.4	118	873	6.1	1,139	264	1,403	348	1,055	10,383	.2470	1.04

Class No.	Kind of Engine.
1	Non-condensing; $r = 1$.
2	" " $r = 2$.
3	" " expanding to back-pressure.
4	Condensing; moderate expansion.
5	" jacketed, full expansion.
6	" jacketed, compound expansion complete.

VI.

COMPARISON OF THERMOMETERS.

Celsius.	Réaumur.	Fahrenheit.	Celsius.	Réaumur.	Fahrenheit.	Celsius.	Réaumur.	Fahrenheit.
—20	—16	—4	25	20.0	77.0	70	56.0	158.0
—19	—15.2	—2.2	26	20.8	78.8	71	56.8	159.8
—18	—14.4	—0.4	27	21.6	80.6	72	57.6	161.6
—17	—13.6	1.4	28	22.4	82.4	73	58.4	163.4
—16	—12.8	3.2	29	23.2	84.2	74	59.2	165.2
—15	—12.0	5.0	30	24.0	86.0	75	60.0	167.0
—14	—11.2	6.8	31	24.8	87.8	76	60.8	168.8
—13	—10.4	8.6	32	25.6	89.6	77	61.6	170.6
—12	—9.6	10.4	33	26.4	91.4	78	62.4	172.4
—11	—8.8	12.2	34	27.2	93.2	79	63.2	174.2
—10	—8.0	14.0	35	28.0	95.0	80	64.0	176.0
—9	—7.2	15.8	36	28.8	96.8	81	64.8	177.8
—8	—6.4	17.6	37	29.6	98.6	82	65.6	179.6
—7	—5.6	19.4	38	30.4	100.4	83	66.4	181.4
—6	—4.8	21.2	39	31.2	102.2	84	67.2	183.2
—5	—4.0	23.0	40	32.0	104.0	85	68.0	185.0
—4	—3.2	24.8	41	32.8	105.8	86	68.8	186.8
—3	—2.4	26.6	42	33.6	107.6	87	69.6	188.6
—2	—1.6	28.4	43	34.4	109.4	88	70.4	190.4
—1	—0.8	30.2	44	35.2	111.2	89	71.2	192.2
0	0	32.0	45	36.0	113.0	90	72.0	194.0
1	0.8	33.8	46	36.8	114.8	91	72.8	195.8
2	1.6	35.6	47	37.6	116.6	92	73.6	197.6
3	2.4	37.4	48	38.4	118.4	93	74.4	199.4
4	3.2	39.2	49	39.2	120.2	94	75.2	201.2
5	4.0	41.0	50	40.0	122.0	95	76.0	203.0
6	4.8	42.8	51	40.8	123.8	96	76.8	204.8
7	5.6	44.6	52	41.6	125.6	97	77.6	206.6
8	6.4	46.4	53	42.4	127.4	98	78.4	208.4
9	7.2	48.2	54	43.2	129.2	99	79.2	210.2
10	8.0	50.0	55	44.0	131.0	100	80.0	212.0
11	8.8	51.8	56	44.8	132.8	101	80.8	213.8
12	9.6	53.6	57	45.6	134.6	102	81.6	215.6
13	10.4	55.4	58	46.4	136.4	103	82.4	217.4
14	11.2	57.2	59	47.2	138.2	104	83.2	219.2
15	12.0	59.0	60	48.0	140.0	105	84.0	221.0
16	12.8	60.8	61	48.8	141.8	106	84.8	222.8
17	13.6	62.6	62	49.6	143.6	107	85.6	224.6
18	14.4	64.4	63	50.4	145.4	108	86.4	226.4
19	15.2	66.2	64	51.2	147.2	109	87.2	228.2
20	16.0	68.0	65	52.0	149.0	110	88.0	230.0
21	16.8	69.8	66	52.8	150.8	111	88.8	231.8
22	17.6	71.6	67	53.6	152.6	112	89.6	233.6
23	18.4	73.4	68	54.4	154.4	113	90.4	235.4
24	19.2	75.2	69	55.2	156.2	114	91.2	237.2

COMPARISON OF THERMOMETERS—*Continued.*

Celsius.	Réaumur.	Fahrenheit.	Celsius.	Réaumur.	Fahrenheit.	Celsius.	Réaumur.	Fahrenheit.
115	92.0	239.0	127	101.6	260.6	139	111.2	282.2
116	92.8	240.8	128	102.4	262.4	140	112.0	284.0
117	93.6	242.6	129	103.2	264.2	141	112.8	285.8
118	94.4	244.4	130	104.0	266.0	142	113.6	287.6
119	95.2	246.2	131	104.8	267.8	143	114.4	289.4
120	96.0	248.0	132	105.6	269.6	144	115.2	291.2
121	96.8	249.8	133	106.4	271.4	145	116.0	293.0
122	97.6	251.6	134	107.2	273.2	146	116.8	294.8
123	98.4	253.4	135	108.0	275.0	147	117.6	296.6
124	99.2	255.2	136	108.8	276.8	148	118.4	298.4
125	100.0	257.0	137	109.6	278.6	149	119.2	300.2
126	100.8	258.8	138	110.4	280.4	150	120.0	302.0

VII.

DENSITIES AND VOLUMES OF WATER.

KOPP; CORRECTED BY PORTER.

Temperature.		Volume, Kopp.	Corrected Volume.	Differences.	
F.	C.				
39.2	4	1.00000	1.00000		
41.0	5	1.00001	1.00001		
51.8	10	1.00025	1.00025	24	34
59.0	15	1.00082	1.00083	58	30
68.0	20	1.00169	1.00171	88	27
77.0	25	1.00284	1.00286	115	24
86.0	30	1.00423	1.00425	139	22
95.0	35	1.00583	1.00586	161	20
104.0	40	1.00768	1.00767	181	19
113.0	45	1.00967	1.00967	200	19
122.0	50	1.01190	1.01186	219	18
131.0	55	1.01423	1.01423	237	18
140.0	60	1.01672	1.01678	255	18
149.0	65	1.01943	1.01951	273	17
150.0	70	1.02238	1.02241	290	17
167.0	75	1.02554	1.02548	307	17
176.0	80	1.02871	1.02872	324	17
185.0	85	1.03202	1.03213	341	16
194.0	90	1.03553	1.03570	357	16
203.0	95	1.03921	1.03943	373	16
212.0	100	1.04312	1.04332	389	

WEIGHTS AND VOLUMES.

Temperature.	Ratio of volume to that of equal weight at maximum density.	Weight of a cubic foot.	Temperature.	Ratio of volume to that of equal weight at maximum density.	Weight of a cubic foot.	Temperature.	Ratio of volume to that of equal weight at maximum density.	Weight of a cubic foot.
Fahr.		Lbs.	Fahr.		Lbs.	Fahr.		Lbs.
32.°	1.000129	62.417	210.°	1.04226	59.894	390.°	1.15538	54.030
39.1	1.000000	62.425	212.	1.04312	59.707	400.	1.16366	53.635
40.	1.000004	62.423	220.	1.04668	59.641	410.	1.17218	53.255
50.	1.000253	62.409	230.	1.05142	59.372	420.	1.18090	52.862
60.	1.000929	62.367	240.	1.05633	59.096	430.	1.18982	52.466
70.	1.001981	62.302	250.	1.06144	58.812	440.	1.19898	52.065
80.	1.00332	62.218	260.	1.06679	58.517	450.	1.20833	51.662
90.	1.00492	62.119	270.	1.07233	58.214	460.	1.21790	51.256
100.	1.00686	62.000	280.	1.07809	57.903	470.	1.22767	50.848
110.	1.00902	61.867	290.	1.08405	57.585	480.	1.23766	50.438
120.	1.01143	61.720	300.	1.09023	57.259	490.	1.24785	50.026
130.	1.01411	61.556	310.	1.09661	56.925	500.	1.25828	49.611
140.	1.01690	61.388	320.	1.10323	56.584	510.	1.26892	49.195
150.	1.01995	61.204	330.	1.11005	56.236	520.	1.27975	48.778
160.	1.02324	61.007	340.	1.11706	55.883	530.	1.29080	48.360
170.	1.02671	60.801	350.	1.12431	55.523	540.	1.30204	47.941
180.	1.03033	60.587	360.	1.13175	55.158	550.	1.31354	47.521
190.	1.03411	60.366	370.	1.13942	54.787			
200.	1.03807	60.136	380.	1.14729	54.411			

VIII.

TEMPERATURES AND PRESSURES, SATURATED STEAM.

IN METRIC MEASURES AND FROM REGNAULT.

Temperature.	Steam-pressure.		Temperature.	Steam-pressure.	
	In Centimetres.	In Atmospheres		In Centimetres.	In Atmospheres
− 32° *C.*	0.0320	0.0004	+ 14° *C.*	1.1908	0.016
31	0.0352	0.0005	15	1.2699	0.017
30	0.0386	0.0005	16	1.3536	0.018
29	0.0424	0.0006	17	1.4421	0.019
28	0.0464	0.0006	18	1.5357	0.020
27	0.0508	0.0007	19	1.6346	0.022
26	0.0555	0.0007	20	1.7391	0.023
25	0.0605	0.0008	21	1.8495	0.024
24	0.0660	0.0009	22	1.9659	0.026
23	0.0719	0.0009	23	2.0888	0.028
22	0.0783	0.0010	24	2.2184	0.029
21	0.0853	0.0011	25	2.3550	0.031
20	0.0927	0.0012	26	2.4988	0.033
19	0.1008	0.0013	27	2.5505	0.034
18	0.1095	0.0014	28	2.8101	0.037
17	0.1189	0.0015	29	2.9782	0.039
16	0.1290	0.0017	30	3.1548	0.042
15	0.1400	0.0018	31	3.3406	0.044
14	0.1518	0.0020	32	3.5359	0.047
13	0.1646	0.0022	33	3.7411	0.049
12	0.1783	0.0024	34	3.9565	0.052
11	0.1933	0.0025	35	4.1827	0.055
10	0.2093	0.0027	36	4.4201	0.058
9	0.2267	0.0030	37	4.6691	0.061
8	0.2455	0.0032	38	4.9302	0.065
7	0.2658	0.0035	39	5.2039	0.068
6	0.2876	0.0038	40	5.4906	0.072
5	0.3113	0.0041	41	5.7910	0.076
4	0.3368	0.0044	42	6.1055	0.080
3	0.3644	0.0048	43	6.4346	0.085
2	0.3941	0.0052	44	6.7790	0.089
1	0.4263	0.0056	45	7.1391	0.094
0	0.4600	0.0061	46	7.5158	0.099
+ 1	0.4940	0.0065	47	7.9093	0.104
2	0.5302	0.0070	48	8.3204	0.109
3	0.5687	0.0073	49	8.7499	0.115
4	0.6097	0.0080	50	9.1982	0.121
5	0.6534	0.0086	51	9.6661	0.127
6	0.6998	0.0092	52	10.1543	0.134
7	0.7492	0.0199	53	10.6636	0.140
8	0.8017	0.0107	54	11.1945	0.147
9	0.8574	0.011	55	11.7478	0.155
10	0.9165	0.012	56	12.3244	0.163
11	0.9792	0.013	57	12.9251	0.170
12	1.0457	0.014	58	13.5505	0.178
13	1.1162	0.015	59	14.2015	0.187

Temperatures and Pressures, Saturated Steam—*Continued.*

Temperature.	Steam-pressure.		Temperature.	Steam-pressure.	
	In Centimetres.	In Atmospheres		In Centimetres.	In Atmospheres
+ 60° *C.*	14.8791	0.196	+110° *C.*	107.537	1.415
61	15.5839	0.205	111	111.209	1.463
62	16.3170	0.215	112	114.983	1.513
63	17.0791	0.225	113	118.861	1.564
64	17.8714	0.235	114	122.847	1.616
65	18.6945	0.246	115	126.941	1.670
66	19.5496	0.257	116	131.147	1.726
67	20.4376	0.267	117	135.466	1.782
68	21.3596	0.281	118	139.902	1.841
69	22.3165	0.294	119	144.455	1.901
70	23.3093	0.306	120	149.128	1.962
71	24.3393	0.320	121	153.925	2.025
72	25.4073	0.334	122	158.847	2.091
73	26.5147	0.349	123	163.896	2.157
74	27.6624	0.364	124	169.076	2.225
75	28.8517	0.380	125	174.388	2.295
76	30.0838	0.396	126	179.835	2.366
77	31.3600	0.414	127	185.420	2.430
78	32.6811	0.430	128	191.147	2.515
79	34.0488	0.448	129	197.015	2.592
80	35.4643	0.466	130	203.028	2.671
81	36.9287	0.486	131	209.194	2.753
82	38.4435	0.506	132	215.503	2.836
83	40.0101	0.526	133	221.969	2.921
84	41.6298	0.548	134	228.592	3.008
85	43.3041	0.570	135	235.373	3.097
86	45.0344	0.593	136	242.316	3.188
87	46.8221	0.616	137	249.423	3.282
88	48.6687	0.640	138	256.700	3.378
89	50.5759	0.665	139	264.144	3.476
90	52.5450	0.691	140	271.763	3.576
91	54.5778	0.719	141	279.557	3.678
92	56.6757	0.746	142	287.530	3.783
93	58.8406	0.774	143	295.686	3.890
94	61.0740	0.804	144	304.026	4.000
95	63.3778	0.834	145	312.555	4.113
96	65.7535	0.865	146	321.274	4.227
97	68.2029	0.897	147	330.187	4.344
98	70.7280	0.931	148	339.298	4.464
99	73.3305	0.965	149	348.609	4.587
100	76.000	1.000	150	358.123	4.712
101	76.7590	1.036	151	367.843	4.840
102	81.6010	1.074	152	377.774	4.971
103	84.5280	1.112	153	387.918	5.104
104	87.5410	1.152	154	398.277	5.240
105	90.6410	1.193	155	408.856	5.380
106	93.8310	1.235	156	419.659	5.522
107	97.1140	1.278	157	430.688	5.667
108	100.4910	1.322	158	441.945	5.815
109	103.965	1.368	159	453.436	5.966

TEMPERATURES AND PRESSURES, SATURATED STEAM—*Continued.*

Temperature.	Steam-pressure.		Temperature.	Steam-pressure.	
	In Centimetres.	In Atmospheres		In Centimetres.	In Atmospheres
+160° *C.*	465.162	6.120	+196° *C.*	1074.595	14.139
161	477.128	6.278	197	1097.500	14.441
162	489.336	6.439	198	1120.982	14.749
163	501.791	6.603	199	1144.746	15.062
164	514.497	6.770	200	1168.896	15.380
165	527.454	6.940	201	1193.437	15.703
166	540.669	7.114	202	1218.369	16.031
167	554.143	7.291	203	1243.700	16.364
168	567.882	7.472	204	1269.430	16.703
169	581.890	7.656	205	1295.566	17.047
170	596.166	7.844	206	1322.112	17.396
171	610.719	8.036	207	1349.075	17.751
172	625.548	8.231	208	1376.453	18.111
173	640.660	8.430	209	1404.252	18.477
174	656.055	8.632	210	1432.480	18.848
175	671.743	8.839	211	1461.132	19.226
176	687.722	9.049	212	1490.222	19.608
177	703.997	9.263	213	1519.748	19.997
178	720.572	9.481	214	1549.717	20.391
179	737.452	9.703	215	1580.133	20.791
180	754.639	9.929	216	1610.994	21.197
181	772.137	10.150	217	1642.315	21.690
182	789.952	10.394	218	1674.090	22.027
183	808.084	10.633	219	1706.329	22.452
184	826.540	10.876	220	1739.036	22.882
185	845.323	11.123	221	1772.213	23.319
186	864.435	11.374	222	1805.864	23.761
187	883.882	11.630	223	1839.994	24.210
188	903.668	11.885	224	1874.607	24.666
189	923.795	12.155	225	1909.704	25.128
190	944.270	12.425	226	1945.292	25.596
191	965.093	12.699	227	1981.376	26.071
192	986.271	12.977	228	2017.961	26.552
193	1007.804	13.261	229	2055.048	27.040
194	1029.701	13.549	230	2092.640	27.535
195	1051.963	13.842			

IX.

METRIC STEAM AND WORK TABLE.

Absolute pressures in Atmosphere.	Specific volumes v_e in Cu. meters.	Product $p_e v_e$.	$W = \frac{26127.34}{1000\, p_e v_e}$	$W \cdot p_e$.
0.1	14.504	1.450	18.010	1.801
0.2	7.525	1.505	17.418	3.483
0.3	5.128	1.540	16.960	5.088
0.4	3.908	1.560	16.750	6.700
0.5	3.165	1.580	16.530	8.265
0.6	2.665	1.600	16.339	9.803
0.7	2.304	1.610	16.230	11.361
0.8	2.031	1.620	16.120	12.896
0.9	1.818	1.630	16.020	14.418
1.0	1.646	1.646	15.870	15.870
1.1	1.505	1.655	15.780	17.385
1.2	1.386	1.663	15.710	18.852
1.3	1.285	1.670	15.640	20.332
1.4	1.199	1.680	15.540	21.756
1.5	1.123	1.684	15.510	23.265
1.6	1.057	1.691	15.450	24.720
1.7	0.999	1.699	15.370	26.129
1.8	0.946	1.703	15.340	27.612
1.9	0.899	1.708	15.290	29.051
2.0	0.857	1.714	15.243	30.486
2.1	0.819	1.718	15.208	31.937
2.2	0.784	1.725	15.146	33.321
2.3	0.751	1.727	15.128	34.794
2.4	0.722	1.733	15.076	36.182
2.5	0.695	1.741	15.002	37.505
2.6	0.670	1.742	14.990	38.974
2.7	0.646	1.744	14.970	40.190
2.8	0.625	1.750	14.929	41.801
2.9	0.604	1.752	14.921	43.271
3.0	0.586	1.758	14.861	44.583
3.1	0.568	1.761	14.838	45.998
3.2	0.551	1.763	14.818	47.417
3.3	0.535	1.765	14.790	48 807
3.4	0.521	1.771	14.749	50.146
3.5	0.507	1.774	14.723	51.330
3.6	0.493	1.775	14.720	52.992
3.7	0.481	1.780	14.680	54.316
3.8	0.469	1.782	14.660	55.708
3.9	0.458	1.786	14.630	57.057
4.0	0.447	1.788	14.61	58.440
4.1	0.437	1.792	14.58	59.778
4.2	0.427	1.793	14.56	61.152
4.3	0.418	1.797	14.53	62.479
4.4	0.409	1.799	14.52	63.888

METRIC STEAM AND WORK TABLE—*Continued.*

Absolute pressure p_0 in Atmospheres.	Specific volumes v_0 in Cu. meters.	Product p_0 v_0.	$W = \frac{26127.34}{1000\ p_0\ v_0}$	W. p_0.
4.5	0.400	1.800	14.51	65.295
4.6	0.392	1.803	14.49	66.654
4.7	0.384	1.805	14.45	67.915
4.8	0.377	1.810	14.43	69.264
4.9	0.370	1.813	14.41	70.609
5.0	0.363	1.815	14.39	71.950
5.1	0.356	1.816	14.38	73.338
5.2	0.350	1.820	14.36	74.672
5.3	0.343	1.821	14.35	76.055
5.4	0.337	1.823	14.33	77.382
5.5	0.332	1.825	14.31	78.705
5.6	0.326	1.826	14.30	80.080
5.7	0.321	1.829	14.26	81.282
5.8	0.316	1.833	14.25	82.650
5.9	0.311	1.835	14.24	84.016
6.0	0.306	1.836	14.23	85.380
6.25	0.294	1.838	14.21	88.812
6.5	0.284	1.845	14.16	92.040
6.75	0.273	1.848	14.13	95.377
7.0	0.265	1.855	14.10	98.700
7.25	0.256	1.856	14.07	100.997
7.5	0.248	1.860	14.04	105.300
7.75	0.241	1.867	13.99	108.422
8.0	0.234	1.872	13.96	111.680
8.25	0.227	1.873	13.95	114.077
8.5	0.221	1.878	13.91	118.235
8.75	0.215	1.881	13.89	121.537
9.0	0.209	1.883	13.86	124.740
9.25	0.204	1.887	13.84	128.020
9.5	0.199	1.891	13.81	131.195
9.75	0.194	1.893	13.80	134.550
10.0	0.190	1.900	13.75	137.500

X.

PROPERTIES OF SATURATED STEAM.

N TE.—The following table gives the data required by the engineer in this connection as based upon the experiments of Regnault. The temperatures, pressures, and heat-measures are all from Regnault's experiments. The other quantities were calculated by Mr. R. H. Buel,* adopting the formulas of Rankine already given to obtain quantities not ascertained by direct experiment. The two parts of the latent heat of vaporization are separately determined, and the internal thus distinguished from the external work of expansion. British measures are adopted. The nomenclature is sufficiently well explained by the table-headings.

Pressure above a vacuum, in pounds per square inch.	Temperature, Fahrenheit degrees.	Quantities of Heat. In British Thermal Units. Required to raise the temperature of the water from 32° to $T°$.	Internal latent heat.	External latent heat.	Latent heat of evaporation at pressure P $= I + E$.	Total heat of evaporation above 32° $= S + L$.	Total heat of evaporation above 32°, in units of evaporation.	Weight of a cubic foot of steam, in pounds.	Volume. Of a pound of steam in cubic feet.	Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density.	Pressure above a vacuum, in pounds per square inch.
P	t	S	I	E	L	H	U	W	C	V	P
1	102.018	70.040	981.396	61.619	1043.015	1113.055	1.1522	.003027	330.4	20,623	1
2	126.302	94.368	961.980	64.114	1026.094	1120.462	1.1599	.005818	171.9	10,730	2
3	141.654	109.764	949.725	65.655	1015.380	1125.144	1.1647	.008522	117.3	7,325	3
4	153.122	121.271	940.597	66.773	1007.370	1128.641	1.1683	.011172	89.51	5,588	4
5	162.370	130.563	933.239	67.660	1000.899	1131.462	1.1712	.013781	72.56	4,530	5
6	170.173	138.401	927.038	68.403	995.441	1133.842	1.1737	.016357	61.14	3,816	6
7	176.945	145.213	921.654	69.041	990.695	1135.908	1.1758	.018908	52.89	3,302	7
8	182.952	151.255	916.883	69.602	986.485	1137.740	1.1777	.021436	46.65	2,912	8
9	188.357	156.699	912.584	70.106	982.690	1139.389	1.1794	.023944	41.77	2,607	9
10	193.284	161.660	908.672	70.560	979.232	1140.892	1.1810	.026437	37.83	2,361	10
11	197.814	166.225	905.083	70.967	976.050	1142.275	1.1824	.028911	34.59	2,159	11
12	202.012	170.457	901.766	71.332	973.098	1143.555	1.1837	.031376	31.87	1,990	12
13	205.929	174.402	898.683	71.663	970.346	1144.748	1.1849	.033828	29.56	1,845	13
14	209.604	178.112	895.784	71.973	967.757	1145.869	1.1861	.036265	27.58	1,721	14
14.69	212.000	180.531	893.894	72.175	966.069	1146.600	1.1869	.037928	26.37	1,646	14.69
15	213.067	181.608	893.044	72.274	965.318	1146.926	1.1872	.038688	25.85	1,614	15
16	216.347	184.919	890.458	72.549	963.007	1147.926	1.1882	.041109	24.33	1,519	16
17	219.452	188.056	888.007	72.811	960.818	1148.874	1.1892	.043519	22.98	1,434	17

* Weisbach's Mechanics, vol ii., part ii., Dubois' translation. N. Y.: J. Wiley & Sons. 1884.

P	t	S	I	E	L	H	U	W	C	V	P
18	222.424	191.058	885.661	73.060	958.721	1149.779	1.1901	.045920	21.78	1,359	18
19	225.255	193.918	883.427	73.298	956.725	1150.643	1.1910	.048312	20.70	1,292	19
20	227.964	196.655	881.289	73.525	954.814	1151.469	1.1919	.050696	19.73	1,231	20
21	230.565	199.285	879.239	73.739	952.978	1152.269	1.1927	.053074	18.84	1,176	21
22	233.069	201.817	877.267	73.942	951.209	1153.026	1.1935	.055446	18.04	1,126	22
23	235.479	204.258	875.368	74.136	949.504	1153.762	1.1943	.057812	17.30	1,080	23
24	237.803	206.610	873.538	74.323	947.861	1154.471	1.1950	.060171	16.62	1,038	24
25	240.053	208.887	871.767	74.503	946.270	1155.157	1.1957	.062524	16.00	998.4	25
26	242.225	211.089	870.052	74.678	944.730	1155.819	1.1964	.064870	15.42	962.3	26
27	244.333	213.223	868.391	74.847	943.238	1156.461	1.1971	.067210	14.88	928.8	27
28	246.376	215.293	866.780	75.011	941.791	1157.084	1.1978	.069545	14.38	897.6	28
29	248.363	217.308	865.215	75.168	940.383	1157.691	1.1984	.071875	13.91	868.5	29
30	250.293	219.261	863.700	75.319	939.019	1158.280	1.1990	.074201	13.48	841.3	30
31	252.171	221.165	862.221	75.466	937.687	1158.852	1.1996	.076522	13.07	815.8	31
32	254.002	223.021	860.781	75.608	936.389	1159.410	1.2002	.078839	12.68	791.8	32
33	255.782	224.827	859.382	75.745	935.127	1159.954	1.2008	.081152	12.32	769.2	33
34	257.523	226.594	858.013	75.878	933.891	1160.485	1.2013	.083461	11.98	748.0	34
35	259.221	228.316	856.680	76.007	932.687	1161.003	1.2018	.085766	11.66	727.9	35
36	260.883	230.001	855.375	76.133	931.508	1161.509	1.2023	.088067	11.36	708.8	36
37	262.505	231.650	854.099	76.255	930.354	1162.004	1.2028	.090364	11.07	690.8	37
38	264.093	233.261	852.852	76.375	929.227	1162.488	1.2033	.092657	10.79	673.7	38
39	265.647	234.840	851.629	76.493	928.122	1162.962	1.2038	.094946	10.53	657.5	39
40	267.168	236.386	850.432	76.608	927.040	1163.426	1.2043	.097231	10.28	642.0	40
41	268.660	237.902	849.261	76.719	925.980	1163.882	1.2048	.099514	10.05	627.3	41
42	270.122	239.389	848.113	76.827	924.940	1164.329	1.2053	.101794	9.826	613.3	42
43	271.557	240.846	846.988	76.932	923.920	1164.766	1.2058	.104071	9.609	599.9	43
44	272.965	242.275	845.884	77.035	922.919	1165.194	1.2062	.106345	9.403	587.0	44
45	274.347	243.680	844.709	77.136	921.935	1165.615	1.2066	.108616	9.207	574.7	45
46	275.704	245.061	843.753	77.235	920.968	1166.029	1.2070	.110884	9.018	563.0	46
47	277.036	246.418	842.687	77.331	920.018	1166.436	1.2074	.113149	8.838	551.7	47
48	278.348	247.752	841.659	77.425	919.084	1166.836	1.2078	.115411	8.665	540.9	48
49	279.637	249.064	840.647	77.517	918.164	1167.228	1.2082	.117670	8.498	530.5	49
50	280.904	250.355	839.653	77.607	917.260	1167.615	1.2086	.119927	8.338	520.5	50
51	282.151	251.624	838.675	77.696	916.371	1167.995	1.2090	.122181	8.185	510.9	51
52	283.381	252.875	837.740	77.784	915.494	1168.369	1.2094	.124433	8.037	501.7	52
53	284.589	254.106	836.762	77.870	914.632	1168.738	1.2098	.126682	7.894	492.8	53
54	285.781	255.321	835.827	77.954	913.781	1169.102	1.2102	.128928	7.756	484.2	54
55	286.955	256.518	834.906	78.036	912.942	1169.460	1.2106	.131172	7.624	475.9	55
56	288.111	257.695	834.001	78.117	912.118	1169.813	1.2110	.133414	7.496	467.9	56
57	289.251	258.857	833.108	78.196	911.304	1170.161	1.2114	.135654	7.372	460.2	57

PROPERTIES OF SATURATED STEAM—(*Continued*).

Pressure above a vacuum, in pounds per square inch.	Temperature, Fahrenheit degrees.	Quantities of Heat. In British Thermal Units. Required to raise the temperature of the water from 32° to T°.	Internal latent heat.	External latent heat.	Latent heat of evaporation at pressure P $= I + E$.	Total heat of evaporation above 32° $= S + L$.	Total heat of evaporation above 32°, in units of evaporation.	Weight of a cubic foot of steam, in pounds.	Volume. Of a pound of steam in cubic feet.	Volume. Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density.	Pressure above a vacuum, in pounds per square inch.
P	t	S	I	E	L	H	U	W	C	V	P
58	290.374	260.002	832.228	78.273	910.501	1170.503	1.2117	.137892	7.252	452.7	58
59	291.483	261.132	831.361	78.348	909.709	1170.841	1.2120	.140128	7.136	445.5	59
60	292.575	262.248	830.507	78.421	908.928	1171.176	1.2123	.142362	7.024	438.5	60
61	293.653	263.348	829.663	78.494	908.157	1171.505	1.2127	.144594	6.916	431.7	61
62	294.717	264.433	828.830	78.566	907.396	1171.829	1.2130	.146824	6.811	425.2	62
63	295.768	265.506	828.005	78.638	906.643	1172.149	1.2133	.149052	6.709	418.8	63
64	296.805	266.566	827.191	78.709	905.900	1172.466	1.2136	.151277	6.610	412.6	64
65	297.830	267.612	826.388	78.779	905.167	1172.779	1.2140	.153500	6.515	406.6	65
66	298.842	268.644	825.596	78.847	904.443	1173.087	1.2143	.155721	6.422	400.8	66
67	299.843	269.666	824.814	78.913	903.727	1173.393	1.2146	.157940	6.332	395.2	67
68	300.831	270.674	824.042	78.978	903.020	1173.694	1.2149	.160157	6.244	389.8	68
69	301.807	271.669	823.280	79.042	902.322	1173.991	1.2152	.162372	6.159	384.5	69
70	302.774	272.657	822.524	79.105	901.629	1174.286	1.2155	.164584	6.076	379.3	70
71	303.728	273.633	821.778	79.167	900.945	1174.578	1.2158	.166794	5.995	374.3	71
72	304.669	274.597	821.041	79.228	900.269	1174.866	1.2161	.169003	5.917	369.4	72
73	305.603	275.550	820.312	79.288	899.600	1175.150	1.2164	.171210	5.841	364.6	73
74	306.526	276.493	819.589	79.349	898.938	1175.431	1.2167	.173417	5.767	360.0	74
75	307.440	277.427	818.873	79.410	808.283	1175.710	1.2170	.175622	5.694	355.5	75
76	308.344	278.350	818.166	79.469	897.635	1175.985	1.2173	.177825	5.624	351.1	76

P	*t*	*S*	*I*	*E*	*L*	*H*	*U*	*W*	*C*	*V*	*P*
77	309.239	279.265	817.468	79.526	896.994	1176.259	1.2176	.180027	5.555	346.8	77
78	310.123	280.170	816.777	79.582	896.359	1176.529	1.2179	.182229	5.488	342.6	78
79	311.000	281.066	816.090	79.639	895.729	1176.795	1.2181	.184429	5.422	338.5	79
80	311.866	281.952	815.413	79.695	895.108	1177.060	1.2184	.186627	5.358	334.5	80
81	312.725	282.830	814.742	79.749	894.491	1177.321	1.2187	.188823	5.296	330.6	81
82	313.576	283.701	814.077	79.802	893.879	1177.580	1.2190	.191017	5.235	326.8	82
83	314.417	284.562	813.419	79.856	893.275	1177.837	1.2193	.193210	5.176	323.1	83
84	315.250	285.414	812.768	79.909	892.677	1178.091	1.2195	.195401	5.118	319.5	84
85	316.076	286.260	812.122	79.961	892.083	1178.343	1.2198	.197591	5.061	315.9	85
86	316.893	287.096	811.484	80.012	891.496	1178.592	1.2200	.190781	5.006	312.5	86
87	317.705	287.927	810.850	80.063	890.913	1178.840	1.2203	.201969	4.951	309.1	87
88	318.510	288.750	810.222	80.113	890.335	1179.085	1.2205	.204155	4.898	305.8	88
89	319.306	289.565	809.601	80.162	889.763	1179.328	1.2208	.206340	4.846	302.5	89
90	320.094	290.373	808.986	80.210	889.196	1179.569	1.2210	.208525	4.796	299.4	90
91	320.877	291.176	808.375	80.258	888.633	1179.809	1.2212	.210709	4.746	296.3	91
92	321.653	291.970	807.770	80.305	888.075	1180.045	1.2215	.212892	4.697	293.2	92
93	322.422	292.758	807.170	80.351	887.521	1180.279	1.2217	.215074	4.650	290.2	93
94	323.183	293.539	806.575	80.397	886.972	1180.511	1.2220	.217253	4.603	287.3	94
95	323.939	294.314	805.985	80.442	886.427	1180.741	1.2222	.219430	4.557	284.5	95
96	324.688	295.083	805.400	80.487	885.887	1180.970	1.2224	.221604	4.513	281.7	96
97	325.431	295.845	804.821	80.531	885.352	1181.197	1.2227	.223778	4.469	279.0	97
98	326.169	296.601	804.245	80.576	884.821	1181.422	1.2229	.225950	4.426	276.3	98
99	326.900	297.350	803.675	80.620	884.295	1181.645	1.2232	.228122	4.384	273.7	99
100	327.625	298.093	803.108	80.665	883.773	1181.866	1.2234	.230293	4.342	271.1	100
101	328.345	298.832	802.544	80.709	883.253	1182.085	1.2236	.232464	4.302	268.5	101
102	329.060	299.566	801.985	80.752	882.737	1182.303	1.2238	.234634	4.262	266.0	102
103	329.769	300.293	801.432	80.794	882.226	1182.519	1.2240	.236803	4.223	263.6	103
104	330.471	301.014	800.884	80.835	881.719	1182.733	1.2242	.238972	4.185	261.2	104
105	331.169	301.731	800.339	80.875	881.214	1182.945	1.2245	.241139	4.147	258.9	105
106	331.862	302.444	799.796	80.916	880.712	1183.156	1.2247	.243304	4.110	256.6	106
107	332.550	303.152	799.258	80.956	880.214	1183.366	1.2249	.245467	4.074	254.3	107
108	333.232	303.854	798.725	80.995	879.720	1183.574	1.2251	.247629	4.038	252.1	108
109	333.911	304.551	798.196	81.034	879.230	1183.781	1.2254	.249789	4.003	249.9	109
110	334.582	305.242	797.672	81.072	878.744	1183.986	1.2256	.251947	3.969	247.8	110
111	335.250	305.927	797.153	81.110	878.263	1184.190	1.2258	.254105	3.935	245.7	111
112	335.914	306.609	796.637	81.147	877.784	1184.393	1.2260	.256263	3.902	243.6	112
113	336.573	307.285	796.125	81.184	877.309	1184.594	1.2262	.258420	3.870	241.6	113
114	337.226	307.956	795.617	81.221	876.838	1184.794	1.2264	.260576	3.838	239.6	114
115	337.874	308.621	795.114	81.257	876.371	1184.992	1.2266	.262732	3.806	237.6	115
116	338.518	309.281	794.614	81.293	875.907	1185.188	1.2268	.264887	3.775	235.7	116
117	339.159	309.939	794.114	81.330	875.444	1185.383	1.2270	.267041	3.745	233.8	117

PROPERTIES OF SATURATED STEAM—(*Continued*).

Pressure above a vacuum, in pounds per square inch.	Temperature, Fahrenheit degrees.	Quantities of Heat. In British Thermal Units. Required to raise the temperature of the water from 32° to $T°$.	Internal latent heat.	External latent heat.	Latent heat of evaporation at pressure $P = I + E$.	Total heat of evaporation above 32° $= S + L$.	Total heat of evaporation above 32°, in units of evaporation.	Weight of a cubic foot of steam, in pounds.	Volume. Of a pound of steam in cubic feet.	Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density.	Pressure above a vacuum, in pounds per square inch.
P	t	S	I	E	L	H	U	W	C	V	P
118	339.796	310.592	793.619	81.366	874.985	1185.577	1.2272	.269195	5.715	231.9	118
119	340.430	311.241	793.126	81.403	874.529	1185.770	1.2274	.271348	3.685	230.1	119
120	341.058	311.885	792.637	81.439	874.076	1185.961	1.2276	.273500	3.656	228.3	120
121	341.681	312.524	792.152	81.474	873.626	1186.150	1.2278	.275651	3.628	226.5	121
122	342.300	313.161	791.669	81.509	873.178	1186.339	1.2280	.277801	3.600	224.7	122
123	342.916	313.795	791.189	81.543	872.732	1186.527	1.2282	.279949	3.572	223.0	123
124	343.528	314.425	790.711	81.578	872.289	1186.714	1.2284	.282097	3.545	221.3	124
125	344.136	315.051	790.236	81.612	871.848	1186.899	1.2286	.284243	3.518	219.6	125
126	344.741	315.672	789.765	81.646	871.411	1187.083	1.2288	.286389	3.492	218.0	126
127	345.340	316.289	789.298	81.679	870.977	1187.266	1.2290	.288533	3.466	216.4	127
128	245.936	316.903	788.834	81.711	870.545	1187.448	1.2292	.290677	3.440	214.8	128
129	346.530	317.513	788.374	81.742	870.116	1187.629	1.2293	.292820	3.415	213.2	129
130	347.121	318.121	787.914	81.774	869.688	1187.809	1.2295	.294961	3.390	211.6	130
131	347.706	318.725	787.458	81.805	869.263	1187.988	1.2296	.297102	3.366	210.1	131
132	348.287	319.325	787.004	81.837	868.841	1188.166	1.2298	.299242	3.342	208.6	132
133	348.867	319.922	786.554	81.868	868.422	1188.344	1.2300	.301382	3.318	207.1	133
134	349.443	320.515	786.105	81.900	868.005	1188.520	1.2302	.303521	3.295	205.7	134
135	350.015	321.105	785.659	81.931	867.590	1188.695	1.2304	.305659	3.272	204.2	135
136	350.584	321.692	785.215	81.962	867.177	1188.869	1.2306	.307797	3.249	202.8	136
137	351.149	322.274	784.775	81.992	866.767	1189.041	1.2308	.309934	3.227	201.4	137
138	351.711	322.853	784.339	82.021	866.360	1189.213	1.2309	.312070	3.204	200.0	138

P	t	S	I	E	L	H	U	W	r	V	P
139	352.271	323.429	783.905	82.050	865.955	1189.384	1.2311	.314205	3.182	198.7	139
140	352.827	324.003	783.472	82.080	865.552	1189.555	1.2313	.316338	3.161	197.3	140
141	353.380	324.573	783.042	82.109	865.151	1189.724	1.2315	.318471	3.140	196.0	141
142	353.931	325.141	782.613	82.138	864.751	1189.892	1.2316	.320603	3.119	194.7	142
143	354.478	325.705	782.188	82.166	864.354	1190.059	1.2318	.322735	3.099	193.4	143
144	355.022	326.265	781.766	82.194	863.960	1190.225	1.2320	.324867	3.078	192.2	144
145	355.562	326.823	781.346	82.221	863.567	1190.390	1.2321	.326998	3.058	190.9	145
146	356.100	327.378	780.927	82.249	863.176	1190.554	1.2323	.329128	3.038	189.7	146
147	356.636	327.930	780.510	82.277	862.787	1190.717	1.2324	.331257	3.019	188.5	147
148	357.169	328.479	780.096	82.304	862.400	1190.879	1.2326	.333386	3.000	187.3	148
149	357.697	329.024	779.684	82.332	862.016	1191.040	1.2328	.335515	2.981	186.1	149
150	358.223	329.566	779.275	82.359	861.634	1191.200	1.2330	.337643	2.962	184.9	150
160	363.345	334.850	775.296	82.616	857.912	1192.762	1.2346	.358886	2.786	173.9	160
170	368.226	339.892	771.505	82.854	854.359	1194.251	1.2361	.380071	2.631	164.3	170
180	372.886	344.708	767.891	83.072	850.963	1195.671	1.2376	.401201	2.493	155.6	180
190	377.352	349.329	764.430	83.273	847.703	1197.032	1.2390	.422280	2.368	147.8	190
200	381.636	353.766	761.111	83.462	844.573	1198.339	1.2404	.443310	2.256	140.8	200
210	385.759	358.041	757.916	83.640	841.556	1199.597	1.2417	.464295	2.154	134.5	210
220	389.736	362.168	754.834	83.808	838.642	1200.810	1.2430	.485237	2.061	128.7	220
230	393.575	366.152	751.862	83.966	835.828	1201.980	1.2442	.506139	1.976	123.3	230
240	397.285	370.008	748.988	84.115	833.103	1203.111	1.2454	.527003	1.898	118.5	240
250	400.883	373.750	746.203	84.256	830.459	1204.209	1.2465	.547831	1.825	114.0	250
260	404.370	377.377	743.508	84.388	827.896	1205.273	1.2476	.568626	1.759	109.8	260
270	407.755	380.905	740.891	84.510	825.401	1206.306	1.2487	.589390	1.697	105.9	270
280	411.048	384.337	738.350	84.623	822.973	1207.310	1.2497	.610124	1.639	102.3	280
290	414.250	387.677	735.878	84.731	820.609	1208.286	1.2507	.630829	1.585	99.0	290
300	417.371	390.933	733.470	84.835	818.305	1209.238	1.2517	.651506	1.535	95.8	300
350	431.96	406.26	722.20	85.28	807.48	1213.74	1.256	.754534	1.325	82.7	350
400	444.92	419.76	712.34	85.60	797.94	1217.70	1.260	.857185	1.167	72.8	400
450	456.62	432.18	703.28	85.84	789.12	1221.30	1.264	.959536	1.042	65.1	450
500	467.42	443.52	695.01	86.01	781.02	1224.54	1.267	1.061700	.942	58.8	500
550	477.50	454.14	687.34	86.12	773.46	1227.60	1.270	1.16380	.859	53.6	550
600	486.86	464.22	680.08	86.18	766.26	1230.48	1.273	1.26586	.790	49.3	600
650	495.68	473.58	673.40	86.20	759.60	1233.18	1.276	1.36791	.731	45.6	650
700	504.14	482.40	667.11	86.19	753.30	1235.70	1.279	1.46995	.680	42.4	700
750	512.06	490.86	661.04	86.14	747.18	1238.04	1.282	1.57198	.636	39.6	750
800	519.62	498.88	665.34	86.08	741.42	1240.30	1.285	1.67401	.597	37.1	800
850	526.82	506.66	649.84	86.00	735.84	1242.50	1.287	1.77603	.563	34.9	850
900	533.66	514.03	644.71	85.91	730.62	1244.65	1.289	1.87804	.532	33.0	900
950	540.32	521.30	639.60	85.80	725.40	1246.70	1.291	1.98004	.505	31.4	950
1000	546.80	528.30	634.68	85.68	720.36	1248.66	1.293	2.08203	.480	30.0	1000

The column headed "*U*" in the table of the properties of saturated steam is useful for reducing the performance of different boilers to a common standard—this standard being that most generally accepted by engineers: the equivalent evaporation at atmospheric pressure and the temperature of boiling water, or, as it is frequently called, the evaporation from and at 212°. In the table it is assumed that the temperature of the feed-water is 32°, and an auxiliary table is added, giving corrections for any temperature of feed from 32° to 212°.

CORRECTION FOR TOTAL HEAT IN UNITS OF EVAPORATION.

Temperature of feed, Fahrenheit degrees.	Correction.	Temperature of feed, Fahrenheit degrees.	Correction.	Temperature of feed, Fahrenheit degrees.	Correction.	Temperature of feed, Fahrenheit degrees.	Correction.	Temperature of feed, Fahrenheit degrees.	Correction.
33	.0010	69	.0383	105	.0756	141	.1129	177	.1504
34	.0021	70	.0393	106	.0766	142	.1140	178	.1514
35	.0031	71	.0404	107	.0777	143	.1150	179	.1525
36	.0041	72	.0414	108	.0787	144	.1160	180	.1535
37	.0052	73	.0424	109	.0797	145	.1171	181	.1545
38	.0062	74	.0435	110	.0808	146	.1181	182	.1556
39	.0073	75	.0445	111	.0818	147	.1192	183	.1566
40	.0083	76	.0456	112	.0829	148	.1202	184	.1577
41	.0093	77	.0466	113	.0839	149	.1213	185	.1587
42	.0104	78	.0476	114	.0849	150	.1223	186	.1598
43	.0114	79	.0487	115	.0860	151	.1233	187	.1608
44	.0124	80	.0497	116	.0870	152	.1244	188	.1618
45	.0135	81	.0507	117	.0880	153	.1254	189	.1629
46	.0145	82	.0518	118	.0891	154	.1264	190	.1639
47	.0155	83	.0528	119	.0901	155	.1275	191	.1650
48	.0166	84	.0538	120	.0911	156	.1285	192	.1660
49	.0176	85	.0549	121	.0922	157	.1296	193	.1670
50	.0186	86	.0559	122	.0932	158	.1306	194	.1681
51	.0197	87	.0569	123	.0943	159	.1316	195	.1691
52	.0207	88	.0580	124	.0953	160	.1327	196	.1702
53	.0217	89	.0590	125	.0963	161	.1337	197	.1712
54	.0228	90	.0601	126	.0974	162	.1348	198	.1723
55	.0238	91	.0611	127	.0984	163	.1358	199	.1733
56	.0248	92	.0621	128	.0994	164	.1368	200	.1743
57	.0259	93	.0632	129	.1005	165	.1379	201	.1754
58	.0269	94	.0642	130	.1015	166	.1389	202	.1764
59	.0279	95	.0652	131	.1025	167	.1400	203	.1775
60	.0290	96	.0663	132	.1036	168	.1410	204	.1785
61	.0300	97	.0673	133	.1046	169	.1420	205	.1796
62	.0311	98	.0683	134	.1057	170	.1431	206	.1806
63	.0321	99	.0694	135	.1067	171	.1441	207	.1817
64	.0331	100	.0704	136	.1077	172	.1452	208	.1827
65	.0342	101	.0714	137	.1088	173	.1462	209	.1837
66	.0352	102	.0725	138	.1098	174	.1473	210	.1848
67	.0362	103	.0735	139	.1109	175	.1483	211	.1858
68	.0372	104	.0746	140	.1119	176	.1493	212	.1869

XI.

TOTAL AVAILABLE ENERGY IN WATER AND STEAM.

Pressure above a vacuum in pounds per square inch.	Same pressure as indicated by steam-gauge, allowing 14.7 pounds for atmospheric pressure.	Absolute pressure in atmospheres.	Number of British thermal units required for the evaporation of one pound of water, known as latent heat of evaporation, *H*.	Temperature in degrees Fahrenheit of the steam and of the water from which it is evaporated.	Temperature in degrees Centigrade of the steam and of the water from which it is evaporated.	Corresponding absolute temperature in degrees Fahrenheit.	Corresponding absolute temperature in degrees Centigrade.	Amount of energy contained in one pound of water which may be liberated by explosion or expansion to 212° Fahr.	Corresponding amount of energy contained in the latent heat of evaporation.	Total amount of energy contained in one pound of steam at corresponding temperatures and pressures.
20	5.3	1.36	954.415	227.9	108.8	689.0	382.8	145.9	16872.9	17018.8
25	10.3	1.70	945.825	240.0	115.5	701.2	389.5	439.7	29156.8	29596.5
30	15.3	2.04	938.925	250.2	121.2	711.4	395.2	813.5	38921.9	39735.4
35	20.3	2.38	932.1523	259.1	126.1	720.3	400.1	1223.4	47054.9	48278.3
40	25.3	2.72	926.4728	267.1	130.1	728.3	404.6	1645.7	54111.7	55757.4
45	30.3	3.06	921.3343	274.2	134.5	735.4	408.5	2112.9	60158.1	62271.0
50	35.3	3.40	916.6316	280.8	138.2	742.0	412.2	2550.4	65613.8	68164.2
55	40.3	3.74	912.2906	286.8	141.5	748.0	415.5	2999.9	70428.7	73428.6
60	45.3	4.08	908.2472	292.5	144.7	753.7	418.7	3449.2	74884.6	78333.8
65	50.3	4.42	904.4621	297.7	147.6	758.9	421.6	3899.8	78850.5	82750.3
70	55.3	4.76	900.8991	302.7	150.4	763.9	424.4	4361.1	82577.7	86938.8
75	60.3	5.10	897.5269	307.3	152.9	768.5	426.9	4815.8	85923.6	90739.4
80	65.3	5.44	894.3304	311.8	155.4	773.0	429.4	5206.5	89138.7	94345.2
85	70.3	5.78	891.2862	316.0	157.7	777.2	431.7	5638.9	92073.3	97712.2
90	75.3	6.12	888.3758	320.0	160.0	781.2	434.0	6058.1	94814.7	100872.8
95	80.3	6.46	885.5887	323.8	162.1	785.0	436.1	6474.2	97447.2	103921.4
100	85.3	6.80	882.9144	327.5	164.1	788.7	438.1	6885.2	99787.6	106672.8
105	90.3	7.14	880.3429	331.1	166.1	792.3	440.1	7290.3	102163.3	109453.6
110	95.3	7.48	877.8653	334.5	168.0	795.7	442.0	7689.0	104334.9	112023.9
115	100.3	7.82	875.4721	337.8	169.8	799.0	443.8	8087.3	106421.7	114509.0
120	105.3	8.16	873.1555	340.9	171.6	802.1	445.6	8483.1	108325.4	116808.5
125	110.3	8.50	870.9115	344.0	173.3	805.2	447.3	8864.9	110219.9	119084.8
130	115.3	8.84	868.7351	347.0	175.0	808.2	449.0	9252.6	112025.6	121278.2
135	120.3	9.18	866.6223	349.9	176.6	811.1	450.6	9627.0	113745.7	123372.7
140	125.3	9.52	864.5661	352.7	178.1	813.9	452.1	9992.6	115382.1	125374.7

TOTAL AVAILABLE ENERGY IN WATER AND STEAM—*Continued.*

Pressure above a vacuum in pounds per square inch.	Same pressure as indicated by steam-gauge, allowing 14.7 pounds for atmospheric pressure.	Absolute pressure in atmospheres.	Number of British thermal units required for the evaporation of one pound of water, known as latent heat of evaporation, *H*.	Temperature in degrees Fahrenheit of the steam and of the water from which it is evaporated.	Temperature in degrees Centigrade of the steam and of the water from which it is evaporated.	Corresponding absolute temperature in degrees Fahrenheit.	Corresponding absolute temperature in degrees Centigrade.	Amount of energy contained in one pound of water which may be liberated by explosion or expansion to 212° Fahr.	Corresponding amount of energy contained in the latent heat of evaporation.	Total amount of energy contained in one pound of steam at corresponding temperatures and pressures.
145	130.3	9.86	862.5679	355.5	179.7	816.7	453.7	10361.0	117003.5	127364.5
150	135.3	10.20	860 6213	358.1	181.1	819.3	455.1	10536.5	118477.2	129003.7
155	140.3	10.54	858.7276	360.7	182.6	821.9	456.6	11085.9	119939.4	131025.3
160	145.3	10.88	856.8740	363.2	184.0	824.4	458.0	11444.2	121323.6	132767.8
165	150.3	11.22	855.0654	365.7	185.4	826.9	459.4	11823.4	122697.8	134521.2
170	155.3	11.56	853.2942	368.1	186.7	829.3	460.7	12141.3	123995.5	136136.8
175	160.3	11.90	851.5670	370.5	188.0	831.7	462.0	12508.7	125284.7	137793.4
180	165.3	12.24	849.8698	372.8	189.3	834.0	463.3	12821.4	126499.1	139320.5
185	170.3	12.58	848.2086	375.0	190.5	836.2	464.5	13182 0	127642.4	140824.4
190	175.3	12.92	846.5844	377.2	191.7	838.4	465.7	13367.1	128778.8	142145.9
195	180.3	13.26	844.9938	379.4	193.0	840.6	467.0	13844.1	129908.3	143752.4
200	185.3	13.60	843.4326	381.5	194.1	842.7	468.1	14153.3	130967.4	145120.7
210	195.3	14.28	840.3967	385.6	196.4	846.8	470.4	14830.8	133003.2	147834.0
220	205.3	14.66	838.5864	389.8	198.7	851.0	472.7	15463.1	136003.3	151466.4
230	215.3	15.64	833.9691	394.2	201.2	855.4	475.2	16180.3	137134.2	153314 7
240	225.3	16.32	832.6419	397.9	203.3	859.1	477.3	16790.2	139094.3	155884.5
250	235.3	17.00	830.3630	401.0	205.0	862.2	479.0	17314.4	140516.0	157830.4
500	485.3	34.01	780.8592	467.6	242.0	898.8	516.0	30055.5	165892.7	195948.2
1000	985.3	68.02	720.4350	546.8	286.0	1008.0	560.0	48671.5	179212.0	227883.5
2000	1985.3	136.05	643.9049	643.7	339.8	1104.9	613.8	75777.2	194221.3	269998.5
3000	2985.3	204.08	590.8038	708.3	375.7	1169.5	649.7	96116.3	193555.0	289671.3
4000	3985.3	272.10	544.6774	763.7	405.9	1223.9	679.9	114498.6	189201.7	303700.3
5000	4985.3	340.13	505.7339	807.8	431.0	1269.0	705.1	130494.2	183305.9	313800. 1
6000	5985.3	408.16	471.8473	845.9	452.1	1307.1	726.1	144413.4	176656.9	321070.3
7000	6985.3	486.19	439.9985	881.2	471.7	1342.4	745.7	157944.2	169333.3	327277.5
8000	7985.3	544.21	409.4533	914.3	490.1	1375.5	764.1	170832.0	161392.6	332224.6
9000	8985.3	612.24	382.6347	945.2	507.3	1406.4	781.5	183998.6	153998.0	337142.6
10000	9985.3	680.27	355.2491	971.4	521.8	1432.6	795.8	193787.0	145376.8	339164.2
100000	99985.3	6802.72	305.3040	2163.4	1184.1	2624.6	1458.1	....	....	....

XII.
FORMULAS RELATING TO PROPERTIES OF STEAM.

QUANTITY.			SYMBOL.	FORMULA.
Pressure.	Above a Vacuum.	Pounds per square inch.	P	$P = \frac{p}{144}$, $\log P = 6.1007 \frac{2731.62}{t} - \frac{396944}{t^2}$
		Pounds per square foot.	p	$p = P \times 144$, $\log p = 8.2591 - \frac{2731.62}{T} - \frac{396944}{T^2}$
		Inches of mercury, at 32° Fahr.	M	$M = P \times 2.03759$
		Feet of distilled water, at temperature of maximum density.	F	$F = P \times 2.306768$
		Atmospheres.	A	$A = P \times 0.0680967$
	Above the atmosphere, in pounds per square inch.		G	$G = P - 14.685$
Temperature.	Fahrenheit's scales.		t	$t = T - 461°.2$
	Absolute scale, Fahrenheit degrees.		T	$T = 1 + \left(\sqrt{\frac{8.2591 - \log p}{396944} + 0.00001184} - 0.003441\right)$
Quantity of heat.	Per pound of steam in British thermal units.	Required to raise the temperature of the water from 32° to t°.	S	$S = t - 32 + 0.000000103(t - 39.1)^3$
		Required to change the water into steam. (Internal latent heat.)	I	$I = L - E$
		Required to overcome the pressure of the surrounding medium. (External latent heat.)	E	$E = p \times \frac{C - v}{772}$
		Latent heat of evaporation, under constant pressure, P.	L	$L = 1091.7 - 0.695(t - 32) - 0.000000103(t - 39.1)^3$
		Total heat of evaporation above 32°.	H	$H = 1091.7 + 0.305(t - 32)$
	Total heat of evaporation per pound of steam, above 32°, in units of evaporation.		U	$U = \frac{H}{966.1}$

FORMULAS RELATING TO PROPERTIES OF STEAM—*Continued.*

QUANTITY.		SYMBOL.	FORMULA.
Foot-pounds of energy, in latent heat of evaporation, per cubic foot of steam.		l	$l = 2.3026 \times p \times \left(\frac{2731.62}{T} + \frac{793888}{T^2}\right)$
Weight.	Of a cubic foot of steam, in pounds.	W	$W = \frac{l}{772 \times L}$
	Of a cubic foot of distilled water, in pounds, at temperature t.	w	$w = \frac{62.425}{v}$
Volume.	Of a pound of steam, in cubic feet.	C	$C = \frac{1}{W}$
	Ratio of volume of steam to volume of equal weight of distilled water at temperature of maximum density.	V	$V = C \times 62.425$
	Ratio of volume of distilled water, at temperature T, to volume of equal weight at temperature of maximum density.	v	For temperatures from 32° to 70°, $v = 1.00012 - 0.000033914(t - 32) + 0.0000023822(t - 32)^2 - 0.000000006403(t - 32)^3$ For temperatures above 70°, $v = 0.99781 + 0.00006117(t - 32) + 0.000001059(t - 32)^2$

XIII.

FACTORS OF EVAPORATION.

Temperature of Feed-water in Degrees.		Gauge Pressure in Pounds per Square Inch Above the Atmosphere and in Atmospheres.															
		25	30	35	40	45	50	60	70	80	90	100	120	140	160	180	200
F.	C.	1.7	2.0	2.3	2.7	3.0	3.3	4.0	4.7	5.3	6.0	6.7	8.0	9.3	10.7	12	13.3
32	0	1.204	1.206	1.209	1.211	1.212	1.214	1.217	1.219	1.222	1.224	1.227	1.231	1.234	1.237	1.239	1.241
35	1.6	.201	.203	.206	.208	.209	.211	.214	.216	.219	.221	.224	.228	.231	.234	.236	.238
40	4.4	.196	.198	.201	.203	.204	.206	.209	.211	.214	.216	.219	.223	.226	.229	.231	.233
45	7.2	.190	.192	.195	.197	.198	.200	.203	.205	.208	.210	.213	.217	.220	.223	.225	.227
50	10	.185	.187	.190	.192	.193	.195	.198	.200	.203	.205	.208	.212	.215	.218	.220	.222
55	12.7	.180	.182	.185	.187	.188	.190	.193	.195	.198	.200	.203	.207	.210	.213	.215	.217
60	15.5	.175	.177	.180	.182	.183	.185	.188	.190	.193	.195	.198	.202	.205	.208	.210	.212
65	18.3	.170	.172	.175	.177	.178	.180	.183	.185	.188	.190	.193	.197	.200	.203	.205	.207
70	21.1	.165	.167	.170	.172	.173	.175	.178	.180	.183	.185	.188	.192	.195	.198	.200	.202
75	23.5	.160	.162	.165	.167	.168	.170	.173	.175	.178	.180	.183	.187	.190	.193	.195	.197
80	26.6	.154	.156	.159	.161	.162	.164	.167	.169	.172	.174	.177	.181	.184	.187	.189	.191
85	29.4	.149	.151	.154	.156	.157	.159	.162	.164	.167	.169	.172	.176	.179	.182	.184	.186
90	32.2	.144	.146	.149	.151	.152	.154	.157	.159	.162	.164	.167	.171	.174	.177	.179	.181
95	35.0	.139	.141	.144	.146	.147	.149	.152	.154	.157	.159	.162	.166	.169	.172	.174	.176
100	37.7	.134	.136	.139	.141	.142	.144	.147	.149	.152	.154	.157	.161	.164	.167	.169	.171
105	40.5	.128	.130	.133	.135	.136	.133	.141	.143	.146	.148	.151	.155	.158	.161	.163	.165
110	43.3	.123	.125	.128	.130	.131	.133	.136	.138	.141	.143	.146	.150	.153	.156	.158	.160
115	46.1	.118	.120	.123	.125	.126	.120	.131	.133	.136	.138	.141	.145	.143	.151	.153	.155
120	48.8	.113	.115	.118	.120	.121	.123	.126	.128	.131	.133	.136	.140	.143	.146	.148	.150
125	51.6	.108	.110	.113	.115	.116	.118	.121	.123	.126	.128	.131	.135	.138	.141	.143	.145
130	54.4	.102	.104	.107	.109	.110	.112	.115	.117	.120	.122	.125	.129	.132	.135	.137	.139
135	57.2	.097	.099	.102	.104	.105	.107	.110	.112	.115	.117	.120	.124	.127	.130	.132	.134
140	60.0	.092	.094	.097	.099	.100	.102	.105	.107	.110	.112	.115	.119	.122	.125	.127	.129
145	62.7	.087	.089	.092	.094	.095	.097	.100	.102	.105	.107	.110	.114	.117	.120	.122	.124
150	65.5	.082	.084	.087	.089	.090	.092	.095	.097	.100	.102	.105	.109	.112	.115	.117	.119
155	68.3	.076	.078	.081	.083	.084	.086	.089	.091	.094	.096	.099	.103	.106	.109	.111	.113
160	71.1	.071	.073	.076	.078	.079	.081	.084	.086	.089	.091	.094	.098	.101	.104	.106	.108
165	73.8	.066	.068	.071	.073	.074	.076	.079	.081	.084	.086	.089	.093	.096	.099	.101	.103
170	76.6	.061	.063	.066	.068	.069	.071	.074	.076	.079	.081	.084	.088	.091	.094	.096	.098
175	79.4	.056	.058	.061	.063	.064	.066	.069	.071	.074	.076	.079	.083	.086	.089	.091	.093
180	82.2	.050	.052	.055	.057	.058	.060	.063	.065	.068	.070	.073	.077	.080	.083	.085	.087
185	85.0	.045	.047	.050	.052	.053	.055	.058	.060	.063	.065	.068	.072	.075	.078	.080	.082
190	87.7	.040	.042	.045	.047	.048	.050	.053	.055	.058	.060	.063	.067	.070	.073	.075	.077
195	90.5	.035	.037	.040	.042	.043	.045	.048	.050	.053	.055	.058	.062	.065	.067	.070	.072
200	93.3	.030	.032	.035	.037	.038	.040	.043	.045	.048	.050	.053	.057	.060	.063	.065	.067
205	96.1	.025	.027	.030	.032	.033	.035	.038	.040	.043	.045	.048	.052	.055	.058	.060	.062
210	98.8	.020	.022	.025	.027	.028	.030	.033	.035	.038	.040	.043	.047	.050	.053	.055	.057

XIV.

COMPOSITION OF VARIOUS FUELS OF THE UNITED STATES.

	C.	H.	O.	N.	S.	Moisture.	Ash.	Spec. Grav.
Pennsylvania Anthracite	78.6	2.5	1.7	0.8	0.4	1.2	14.8	1.45
Rhode Island "	85.8	10.5		....	3.7	....	....	1.85
Massachusetts "	92 0	6.0		....	2.0	....	....	1.78
North Carolina "	83.1	7.8		....	9.1	....	....	....
Welsh "	84.2	3.7	2.3	0.9	0.9	1.3	6.7	1.40
Maryland Semi-bituminous	80.5	4.5	2.7	1.1	1.2	1.7	8.3	1.33
Pennsylvania "	75.8	20.2		....	....	....	4.0	1.32
" "	59.4	38.8		....	....	....	1.8	1.30
Indiana "	70.0	28.0		....	....	....	2.0	1.24
" "	52.0	39.0		....	....	....	9.0	1.27
Illinois Bituminous	62.6	35.5		....	....	...	1.9	1.30
" (Block) Bituminous	58.2	37.1		....	...	....	4.7	....
Illinois and Indiana (Cannel) Bituminous	59.5	36.6		....	....	....	3.9	1.27
Kentucky (Cannel) Bituminous	48.4	48.8		....	....	....	2.8	1.25
Tennessee Bituminous	71.0	17.0		....	....	....	12.0	1.45
" "	41.5	56.5		....	....	....	2.5	....
Alabama "	54.0	42.6		....	1.0	1.2	1.2	....
Virginia "	55.0	41.0		....	....	....	4.0	....
" "	74.0	18.6		....	....	....	7.4	....
California and Oregon Lignite	50.1	3.9	13.7	0.9	1.5	16.7	13.2	1.32

Coal. State.	Coal. Kind of Coal.	Per Cent. of Ash.	Theoretical Value. In Heat Units.	Theoretical Value. In Pounds of Water Evaporated.
Pennsylvania	Anthracite	3.49	14,199	14.70
"	"	6.13	13,535	14.01
"	"	2.90	14,221	14.72
"	Cannel	15.02	13,143	13.60
"	Connelsville	6.50	13,368	13.84
"	Semi-bituminous	10.77	13,155	13.62
"	Stone's Gas	5.00	14,021	14.51
"	Youghiogheny	5.60	14,265	14.76
"	Brown	9.50	12,324	12.75
Kentucky	Caking	2.75	14,391	14.89
"	Cannel	2.00	15,198	16.76
"	"	14.80	13,360	13.84
"	Lignite	7.00	9,326	9.65
Illinois	Bureau County	5.20	13,025	13.48
"	Mercer County	5.60	13,123	13.58
"	Montauk	5.50	12,659	13.10
Indiana	Block	2.50	13,588	14.38
"	Caking	5.66	14,146	14.64
"	Cannel	6.00	13,097	13.56
Maryland	Cumberland	13.98	12,226	12.65
Arkansas	Lignite	5.00	9,215	9.54
Colorado	"	9.25	13,562	14.04
"	"	4.50	13,866	14.35
Texas	"	4.50	12,962	13.41
Washington	"	3.40	11,551	11.96
Pennsylvania	Petroleum	....	20,746	21.47

ANALYSES OF ASH.

	Specific Grav.	Color of Ash.	Silica.	Alumina.	Oxide Iron.	Lime.	Magnesia.	Loss.	Acids S.&P.
Pennsylvania Anthracite.....	1.559	Reddish Buff.	45.6	42.75	9.43	1.41	0.33	0.48	....
" Bituminous....	1.372	Gray.	76.0	21.00	2.60	....	..	0.40	....
Welsh Anthracite............	1.32	....	40.0	44.8	....	12.0	trace	....	2.97
Scotch Bituminous...........	1.26	...	37.6	52.0	....	3.7	1.1	....	5.02
Lignite......................	1.27	....	19.3	11.6	5.8	23.7	2.6	....	33.8

XV.

HORSE-POWER PER POUND MEAN PRESSURE.

Diameter of Cylinder. Inches.	Speed of Piston in Feet per Minute.										
	100	240	300	350	400	450	500	550	600	650	750
4	.038	.091	.114	.133	.152	.171	.19	.209	.228	.247	.285
4½	.048	.115	.144	.168	.192	.216	.24	.264	.288	.312	.360
5	.06	.144	.18	.21	.24	.27	.30	.33	.36	.39	.450
5½	.072	.173	.216	.252	.288	.324	.36	.396	.432	.468	.540
6	.086	.205	.256	.299	.342	.385	.428	.471	.513	.555	.641
6½	.102	.245	.307	.391	.409	.464	.512	.563	.614	.698	.800
7	.116	.279	.348	.408	.466	.524	.583	.641	.699	.756	.874
7½	.134	.321	.401	.468	.534	.602	.669	.735	.802	.869	1.002
8	.152	.365	.456	.532	.608	.685	.761	.837	.912	.989	1.121
8½	.172	.413	.516	.602	.688	.774	.86	.946	1.032	1.118	1.290
9	.192	.462	.577	.674	.770	.866	.963	1.059	1.154	1.251	1.444
9½	.215	.515	.644	.751	.859	.966	1.074	1.181	1.288	1.395	1.610
10	.238	.571	.714	.833	.952	1.071	1.190	1.309	1.428	1.547	1.785
10½	.262	.63	.787	.919	1.050	1.181	1.313	1.444	1.575	1.706	1.969
11	.288	.691	.864	1.008	1.152	1.296	1.44	1.584	1.728	1.872	2.160
11½	.314	.754	.943	1.1	1.257	1.414	1.572	1.729	1.886	2.043	2.357
12	.342	.820	1.025	1.195	1.366	1.540	1.708	1.880	2.050	2.222	2.564
13	.402	.964	1.206	1.407	1.608	1.809	2.01	2.211	2.412	2.613	3.015
14	.466	1.119	1.398	1.631	1.864	2.097	2.331	2.564	2.797	3.029	3.495
15	.535	1.285	1.606	1.873	2.131	2.409	2.677	2.945	3.212	3.479	4.004
16	.609	1.461	1.827	2.131	2.436	2.741	3.045	3.349	3.654	3.958	4.567
17	.685	1.643	2.054	2.396	2.739	3.081	3.424	3.766	4.108	4.450	5.135
18	.771	1.849	2.312	2.697	3.083	3.468	3.854	4.239	4.624	5.009	5.780
19	.859	2.061	2.577	3.006	3.436	3.865	4.295	4.724	5.154	5.583	6.442
20	.952	2.292	2.855	3.331	3.807	4.285	4.759	5.234	5.731	6.186	7.138
21	1.049	2.518	3.148	3.672	4.197	4.722	5.247	5.771	6.296	6.820	7.869
22	1.152	2.764	3.455	4.031	4.607	5.183	5.759	6.334	6.911	7.486	8.638
23	1.259	3.021	3.776	4.405	5.035	5.664	6.294	6.923	7.552	8.181	9.44
24	1.370	3.289	4.111	4.797	5.482	6.167	6.853	7.538	8.223	8.908	10.279
25	1.487	3.569	4.461	5.105	5.948	6.692	7.436	8.179	8 923	9.566	11.053
26	1.609	3.861	4.826	5.630	6.435	7.239	8.044	8.848	9.652	10.456	12.065
27	1.733	4.159	5.199	6.066	6.932	7.799	8.666	9.532	10.399	11.265	12.998
28	1.865	4.477	5.596	6.529	7.462	8.395	9.328	10.261	11.193	12.125	13.991
29	2.002	4.805	6.006	7.007	8.008	9.009	10.01	11.011	12.012	13.013	15.015
30	2.142	5.141	6.426	7.497	8.568	9.639	10.71	11.781	12.852	13.923	16.065
31	2.288	5.486	6.865	8.001	9.144	10.287	11.43	12.573	13.716	14.866	17.145
32	2.436	5.846	7.308	8.526	9.744	10.962	12.18	13.398	14.616	15.834	18.270
33	2 590	6.216	7.770	9.065	10.360	11.655	12.959	14.245	15.54	16.835	19.425
34	2.746	6.59	8.238	9.611	10.984	12.357	13.73	15.103	16.476	17.849	20.595
35	2.914	6.993	8.742	10.199	11.656	13.113	14.57	16.027	17.484	18.941	21.855
36	3.084	7.401	9.252	10.794	12.336	13.878	15.42	16.962	18.504	20.046	23.130
37	3.253	7.819	9.774	11.403	13.032	14.861	16.29	17.919	19.548	21.177	24 435
38	3.436	8.246	10.308	12.026	13.744	15.462	17.18	18.898	20.616	22.334	25.770
39	3.620	8.648	10.86	12.67	14.48	16.29	18.1	19.91	21.62	23.53	27.150
40	3.808	9.139	11.424	13.328	15.232	17.136	19.04	20.944	22.848	24.752	28.560
41	4.002	9.604	12.006	14.007	16.008	18.009	20.00	22.011	24.012	26.013	30.015
42	4.198	10.065	12.594	14.693	16.792	18.901	20.99	23.089	25.188	27.287	31.485
43	4.40	10.56	13.20	15.4	17.6	19.8	22.00	24.2	26.4	28.6	33.00
44	4.606	11.046	13.818	16.121	18.424	20.727	23.03	25.333	27.636	29.939	34.545
45	4.818	11.563	14.454	16.863	19.272	21.681	24.09	26.399	28.908	31.317	36.135
46	5.043	12.086	15.128	17.626	20.144	22.662	25.18	27.698	30.216	32.754	37.770
47	5.256	12.614	15.768	18.396	21.024	23.652	26.28	28.908	31.536	34.164	39.420
48	5.482	12.846	16.446	19.187	21.928	24.669	27.41	30.151	32 152	35.633	41.115
49	5.714	12.913	17.142	19.999	22.856	25.713	28.57	31.427	34.284	37.141	42.855
50	5.950	14.28	17.85	20.825	23.8	26.775	29.75	32.725	35.7	38.675	44.625
51	6.180	14.832	18.54	21.665	24.76	27.855	30.95	34.045	37.08	40.205	46.425
52	6.432	15.437	19.296	22.512	25.728	28.944	32.16	35.376	38.592	41.808	48 240
53	6.684	16.041	20.052	23.394	26.736	30.078	33.42	36.762	40.104	43.446	50.130
54	6.940	16.656	20.82	24.29	27.76	31.23	34.7	38.17	41.64	45.11	52.05
55	7.198	17.275	21.594	25.193	28.792	32.391	35.99	39.589	43.188	46.787	53.985
56	7.462	17.909	22.386	26.117	29 848	33.579	37.31	41.041	44.772	48.503	55.965
57	7.732	18.557	23.196	27.062	30.928	34.794	38.66	42.526	46.392	50.258	57.99
58	8.006	19 214	24.018	28.021	32.024	36.027	40.03	44.033	48.036	52.039	60.045
59	8.284	19.902	24.852	28.964	33.136	37.278	41.42	45.562	48.704	53.846	62.13
60	8.566	20.558	25.698	29.981	34.264	38.547	42.83	47.113	51.396	55.679	64.245

XVI.

REAL RATIOS OF EXPANSION.

Per cent. of Clearance.	Points of Cut-off.														
	.10	.125	.20	.25	.30	.333	.375	.40	.50	.60	.625	.70	.75	.80	.875	.90
.01	9.111	7.481	4.809	3.884	3.258	2.944	2.623	2.463	1.983	1.655	1.590	1.422	1.328	1.246	1.141	1.109
.0125	9	7.363	4.764	3.875	3.24	2.930	2.612	2.454	1.975	1.653	1.588	1.421	1.327	1.246	1.140	1.109
.0150	8.826	7.25	4.720	3.830	3.222	2.916	2.602	2.445	1.970	1.650	1.585	1.419	1.326	1.245	1.140	1.109
.0175	8.659	7.133	4.677	3.803	3.204	2.902	2.592	2.436	1.966	1.647	1.583	1.418	1.325	1.244	1.140	1.108
.02	8.5	7.034	4.635	3.777	3.187	2.889	2.582	2.428	1.961	1.645	1.581	1.416	1.325	1.243	1.138	1.108
.0225	8.346	6.932	4.595	3.752	3.170	2.876	2.574	2.420	1.956	1.642	1.579	1.415	1.324	1.243	1.138	1.108
.0250	8.2	6.833	4.555	3.727	3.153	2.863	2.562	2.411	1.952	1.640	1.576	1.413	1.322	1.242	1.138	1.108
.0275	8.088	6.738	4.516	3.702	3.137	2.850	2.552	2.403	1.947	1.637	1.574	1.412	1.321	1.241	1.138	1.107
.03	7.933	6.645	4.417	3.678	3.121	2.837	2.543	2.395	1.943	1.634	1.572	1.410	1.320	1.240	1.138	1.107
.0325	7.792	6.555	4.440	3.654	3.105	2.824	2.533	2.387	1.938	1.632	1.570	1.409	1.319	1.240	1.138	1.107
.0350	7.666	6.468	4.404	3.631	3.089	2.812	2.524	2.379	1.934	1.629	1.568	1.408	1.318	1.239	1.137	1.106
.0375	7.545	6.390	4.484	3.608	3.074	2.800	2.515	2.371	1.930	1.627	1.566	1.406	1.317	1.238	1.136	1.106
.04	7.428	6.303	4.333	3.58	3.058	2.788	2.506	2.363	1.925	1.625	1.563	1.405	1.316	1.238	1.136	1.106
.0425	7.315	6.229	4.298	3.564	3.043	2.776	2.497	2.355	1.921	1.622	1.561	1.404	1.315	1.237	1.136	1.106
.0450	7.206	6.147	4.256	3.542	3.028	2.764	2.488	2.348	1.917	1.620	1.569	1.402	1.314	1.236	1.135	1.105
.0475	7.102	6.082	4.232	3.521	3.014	2.752	2.479	2.340	1.913	1.617	1.557	1.401	1.313	1.235	1.135	1.105
.05	7	6	4.2	3.5	3	2.741	2.470	2.333	1.907	1.615	1.555	1.400	1.312	1.235	1.135	1.105
.0525	6.901	5.985	4.168	3.478	2.986	2.730	2.461	2.325	2.904	1.613	1.553	1.398	1.311	1.234	1.134	1.104
.0550	6.806	5.861	4.130	3.459	2.971	2.719	2.453	2.318	1.900	1.610	1.551	1.397	1.310	1.233	1.134	1.104
.0575	6.714	5.794	4.106	3.439	2.957	2.708	2.445	2.311	1.896	1.608	1.549	1.396	1.309	1.233	1.134	1.104
.06	6.625	5.729	4.076	3.418	2.944	2.697	2.436	2.304	1.892	1.606	1.547	1.394	1.308	1.232	1.133	1.104
.0625	6.538	5.666	4.047	3.407	2.931	2.686	2.428	2.297	1.888	1.603	1.545	1.393	1.307	1.231	1.133	1.103
.0650	6.454	5.605	4.045	3.380	2.917	2.675	2.420	2.290	1.884	1.601	1.343	1.392	1.306	1.231	1.132	1.103
.0675	6.373	5.545	3.990	3.362	2.904	2.665	2.412	2.283	1.881	1.599	1.541	1.390	1.305	1.230	1.132	1.103
.07	6.294	5.482	3.963	3.342	2.892	5.655	2.404	2.276	1.877	1.597	1.539	1.389	1.304	1.229	1.132	1.103

XVII.

A.

LOG OF TRIAL BY MECHANICAL LABORATORY, DEPARTMENT OF ENGINEERING.

Test made at______________________________

____

on____________________________________

$$x = \frac{U - wh}{H - h}$$

$$\frac{\frac{U}{w} + t - T}{0.48} = \text{Degrees of Superheating.}$$

Time.	Pressures.			Temperatures.					Weights.			Remarks.
										Feed-water.		
	Barometer.	Steam-gauge	Draught-gauge.	External Air.	Boiler-room.	Fuel.	Feed-water.	Steam.	Fuel.	Per Metre.	Per Tank.	

PRIMING TESTS.

No.	Time.	Steam-pressures.	Calorimeter.					Heat-units per Pound from Boiler.		Heat transferred to Calorimeter. $W \times R = U$	Heat from Steam $H = T - t'$	Heat from Water $h = t - t'$	Steam run into Calorimeter. x	Percentage of Priming. y	Super-heating.		Remarks.
			Weights.		Temperature.												
			Condensing Water. W	Wet Steam. w	Initial. t''	Final t'	Range. $R = t' - t''$	Water. t	Steam. T						Degrees.	Heat-units.	

XVII.—(*Continued.*)

B.

AVERAGE AND TOTAL RESULTS OF TRIAL, MECHANICAL LABORATORY, DEPARTMENT OF ENGINEERING.

Trial made at________________ Fuel________________

on________________ Composition________________

Number of Trial.	Date of Trial.	Length of Trial.	Areas.				Ratio of Grate to Heating-surface.	Average Temperatures.				Average Pressures.			Consumption of Fuel.			Ashes.		Total Combustible.	Remarks.
			Grate.	Heating-surface.	Super-heating-surface.	Least Cross-section of Flues.		Boiler-room.	External Air.	Entrance to Chimney.	Feed-water.	Barometer.	Steam-gauge.	Draught-gauge.	Total.	Per square foot of Grate per hour.	Per sq. ft. of Heating-surface per hour.	Total.	Proportion of Total Fuel.		
		Hours.	sq. ft.	sq. ft.	sq. ft.	sq. ft.		Fahr.	Fahr.	Fahr.	Fahr.	ins.	lbs.	ins.	lbs.	lbs.	lbs.	lbs.	per ct.	lbs.	

Apparent Evaporation.									Real Evaporation.														
Per Pound of Fuel.			Per Pound of Combustible.			Per Square Foot of Heating-surface, per Hour.			Per Pound of Fuel.			Per Pound of Combustible.			Per Square Foot of Heating-surface, per Hour.			Square feet of Heating-surface required to Evaporate one Cubic Foot of Water.					
From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.			
lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	sq. ft.	sq. ft.	sq. ft.			

XVII.—(*Continued.*)

B.

Total Water fed to Boiler.			Average. Priming	Total Water Primed.	Water Evaporated into Dry Steam.			Remarks.
From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.			From actual temperature of feed-water and at actual steam-pressure.	Equivalent from and at 212° F.	Equivalent from 212° F. and at actual steam-pressure.	
lbs.	lbs.	lbs.	per cent.	lbs.	lbs.	lbs.	lbs.	

Average Amount of Superheating.	Evaporation from and at 212° F., Equivalent to Total Heat-units derived from Fuel.			Efficiency.			Values of A and B in $F = A\sqrt{H} + B$.		Horse-power.		Remarks.
	Per Pound of Fuel.	Per Pound of Combustible.	Per sq. ft. of Heating-surface per hour.	Experimental.	Estimated.	$R = \frac{\text{Experimental.}}{\text{Estimated.}}$	A	B	Rated.	Actual.	
Fahr.	lbs.	lbs.	lbs.	per cent.	per cent.						

XVII.

C.

CONDENSED LOG OF ENGINE-TRIAL.

Date,——————1891.

		Revolutions.		Gauge Readings.						Temperatures.										Weights.				Head.		Crank.			Brake.		
				Pounds.			Inches Hg.									Calorim. (Throttling, Temp.).															
Number.	Time.	Continuous Counter.	Speed-indicator.	Boiler.	Steam-pipe.	Steam-chest.	Exhaust.	Condenser.	Barometer.	External Air.	Engine-room.	Condensed Steam.	Feed-water.	Injection-water.	Discharge-water.	Steam-pipe.	Steam-chest.	Cylinder.	Exhaust.	Condensed Steam.	Feed-water.	Injection-water.		M. E. P.	I. H. P.	M. E. P.	I. H. P.	I. H. P. Total.	Load.	D. H. P.	Scale of Spring.

Clearance, Head lbs. Water......	Diam. Piston-rod, inches........	Areas, square inches...........	*Test made by*
" Crank " "	Diam. Crank-pin, inches	Piston........................	....
Brake-arm.	Length Crank-pin	Steam-port	
Diam. Cylinder, inches..........	Diam. Wrist-pin, inches.........	Exhaust-port	....
Length Stroke.......	Travel-valve, inches............	....	....
	Lap of Valve, inches...........		

XVIII.

ELECTRICAL HORSE-POWER TABLE. By H. W. Fisher, M.E.

VOLTS OR AMPERES.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	.00134	.00268	.00402	.00536	.00670	.00804	.00938	.01072	.01206	.01340	.01474	.01608	.01742	.01876	.02010	.02144	.02278	.02412	.02546	.02680	1
2	.00268	.00536	.00804	.01072	.01340	.01608	.01876	.02144	.02412	.02680	.02948	.03216	.03484	.03752	.04020	.04288	.04556	.04824	.05092	.05360	2
3	.00402	.00804	.01206	.01608	.02010	.02412	.02814	.03216	.03618	.04020	.04422	.04824	.05226	.05628	.06030	.06432	.06834	.07236	.07638	.08040	3
4	.00536	.01072	.01608	.02144	.02680	.03216	.03752	.04288	.04824	.05360	.05896	.06432	.06968	.07504	08040	.08576	.09112	.09648	.10184	.10720	4
5	.00670	.01340	.02010	.02680	.03350	.04020	.04690	.05360	.06030	.06700	.07370	.08040	.08710	.09380	.10050	.10720	.11390	.12060	.12730	.13400	5
6	.00804	.01608	.02412	.03216	.04020	.04824	.05628	.06432	.07236	.08040	.08844	.09648	.10452	.11256	.12060	.12864	.13668	.14472	.15276	.16080	6
7	.00938	.01876	.02814	.03752	.04690	.05628	.06566	.07504	.08442	.09380	.10318	.11256	.12194	.13132	.14070	.15008	.15946	.16884	.17822	.18760	7
8	.01072	.02144	.03216	.04288	.05360	.06432	.07504	.08576	.09648	.10720	.11792	.12864	.13936	.15008	.16080	.17152	.18224	.19296	.20368	.21440	8
9	.01206	.02412	.03618	.04824	.06030	.07236	.08442	.09648	.10834	.12060	.13266	.14472	.15678	.16884	.18090	.19296	.20502	.21708	.22914	.24120	9
10	.01340	.02680	.04020	.05360	.06700	.08040	.09380	.10720	.1[illegible]060	.13400	.14740	.16080	.17420	.18760	.20100	.21440	.22780	.24120	.25460	.26800	10
11	.01474	.02948	.04422	.05896	.07370	.08844	.10318	.11792	.13266	.14740	.16214	.17688	.19162	.20636	.22110	.23584	.25058	.26532	.28006	.29480	11
12	.01608	.03216	.04824	.06432	.08040	.09648	.11256	.12864	.14470	.16080	.17688	.19296	.20904	.22512	.24120	.25728	.27336	.28944	.30552	.32160	12
13	.01742	.03484	.05226	.06968	.08710	.10452	.12194	.139[illegible]6	.15678	.17420	.19162	.20904	.22646	.24388	.26130	.27872	.29614	.31356	.33098	.34840	13
14	.01876	.03752	.05628	.07504	.09380	.11256	.13132	.15008	.10884	.18760	.20636	.22512	.24388	.26264	.28140	.30016	.31892	.33768	.35644	.37520	14
15	.02010	.04020	.06030	.08040	.10050	.12060	.14070	.16080	.18090	.20100	.22110	.24120	.26130	.28140	.30150	.32160	.34170	.36180	.38190	.40200	15
16	.02144	.04288	.06432	.08576	.10720	.12864	.15008	.17152	19296	.21440	.23584	.25728	.27872	.30016	.32160	.34304	.36448	.38592	.40736	.42880	16
17	.02278	.04556	.06834	.09112	.11390	.13668	.15946	.18224	.20502	.22780	.25058	.27336	.29614	.31892	.34170	.36448	.38726	.41004	.43282	.45560	17
18	.02412	.04824	.07236	.09648	.12060	.14472	.16884	.19296	.21708	.24120	.26532	.28944	.31356	.33768	.36180	.38592	.41004	.43416	.45828	.48240	18
19	.02546	.05092	.07638	.10184	.12730	.15276	.17822	.20368	.22914	.25460	.28006	.30552	.33098	.35644	.38190	.40736	.43282	.45828	.48374	.50920	19
20	.02680	.05360	.08040	.10720	.13400	.16080	.18760	.21440	.24120	.26800	.29480	.32160	.34840	[illegible]7520	.40200	.42880	.45560	.48240	.50920	.53600	20
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	

VOLTS OR AMPERES.

VOLTS OR AMPERES. (left margin)

VOLTS OR AMPERES. (right margin)

HORSE-POWER TABLE.

The product of volts and amperes measures electrical energy or power. Dividing by 746 reduces electrical energy to horse-power.

Examples:—1st. What electrical horse-power corresponds to 19 amperes and 12 volts?
2d. " " " " " " 190 " " 120 "
3d. " " " " " " 1900 " " 120 "

At the juncture of columns 12 and 19 we find .30552, which is the required horse-power for Example No. 1.

In Example No. 2 there are two significant figures after the 19 and 12, hence we move the decimal point two places to the right and the answer is 30.552 H. P.

There are three significant figures in Example No. 3, hence the horse-power is 305.52.

Now suppose we have 2500 volts and 45 amperes. In this case we must take

The horse-power for
- 2000 volts and 40 amperes = 107.2
- 2000 " " 5 " = 13.4
- 500 " " 40 " = 26.8
- 500 " " 5 " = 3.25

Total horse-power = 150.75

XIX.

WATER-COMPUTATION TABLE.

T. P.	0	1	2	3	4	5	6	7	8	9
3	117.300	121.015	124.717	128.406	132.083	135.748	139.399	143.075	146.665	150.279
4	153.880	157.514	161.137	164.750	168.353	171.945	175.527	179.098	182.659	186.210
5	189.750	193.336	196.914	200.483	204.044	207.598	211.142	214.679	218.208	221.728
6	225.240	228.799	232.351	235.897	239.437	242.970	246.497	250.017	253.531	257.039
7	260.540	264.056	267.566	271.071	274.570	278.063	281.550	285.031	288.506	291.976
8	295.440	298.922	302.400	305.872	309.338	312.800	316.256	319.708	323.154	326.594
9	330.030	333.488	336.941	340.389	343.833	347.273	350.707	354.137	357.563	360.984
10	364.400	367.842	371.280	374.714	378.144	381.570	384.992	388.410	391.824	395.234
11	398.640	402.064	405.485	408.902	412.315	415.725	419.131	422.534	425.933	429.328
12	432.720	436 120	439.517	442.911	446.301	449.688	453.071	456.451	459.828	463.200
13	466.570	469.950	473.326	476.699	480.068	483.435	486.798	490.159	493.516	496.869
14	500.220	503.596	506.968	510.338	513.706	517.070	520 432	523.790	527.146	530.500
15	533.850	537.213	540.573	543.930	547.285	550.638	553.987	557.334	560.679	564.011
16	567.360	570.713	574.063	577.411	580.757	584.100	587.441	590.780	594.115	597.449
17	600.780	604.109	607.435	610.759	614.081	617.400	620.717	624.031	627.343	630.653
18	633.960	637.265	640.567	643.867	647.165	650.460	653.753	657.043	660.331	663.617
19	666.900	670.200	673.498	676.793	680.086	683.378	686.666	689.953	693.238	696.520
20	699.800	703.098	706.394	709.688	712.980	716.270	719.558	722.844	726.128	729.410
21	732.690	735.968	739.244	742.518	745.790	749.060	752.328	755.594	758.858	762.120
22	765.380	768.660	771.938	775.215	778.490	781.763	785.034	788.303	791.570	794.836
23	798.100	801.362	804.622	807.881	811.138	814.393	817.646	820.897	824.146	827.334
24	830.640	833.908	837.175	840.440	843.703	846.965	850.225	853.484	856.741	859.996
25	863.250	866.502	869.753	873.002	876.249	879.495	882.739	885.982	889.223	892.462
26	895.700	898.936	902.171	905.404	908.635	911.865	915.093	918.320	921.545	924.768
27	927.990	931.210	934.429	937.646	940.831	944.075	947.287	950.498	953.707	956.914
28	960.120	963.352	966.583	969.813	973.041	976.268	979.493	982.717	985.939	989.160
29	992.380	995.598	998.815	1002.031	1005.245	1008.458	1011.669	1014.879	1018.087	1021.294
30	1024.500	1027.704	1030.907	1034.109	1037.309	1040.508	1043.705	1046.901	1050.095	1053.288
31	1056.480	1059.670	1062.859	1066.047	1069.233	1072.418	1075.601	1078.783	1081.963	1085.142

XIX.—(*Continued.*)

WATER-COMPUTATION TABLE—*Continued.*

T. P.	0	1	2	3	4	5	6	7	8	9
32	1088.320	1091.528	1094.736	1097.942	1101.146	1104.350	1107.552	1110.754	1113.954	1117.152
33	1120.350	1123.546	1126.742	1129.936	1133.128	1136.420	1139.510	1142.700	1145.888	1149.074
34	1152.260	1155.444	1158.628	1161.810	1164.990	1168.170	1171.348	1174.526	1177.702	1180.876
35	1184.050	1187.222	1190.394	1193.564	1196.732	1199.900	1203.066	1206.232	1209.396	1212.558
36	1215.720	1218.917	1222.112	1225.307	1228.500	1231.693	1234.884	1238.075	1241.264	1244.453
37	1247.640	1250.827	1254.012	1257.197	1260.380	1263.563	1266.744	1269.925	1273.104	1276.283
38	1279 460	1282.637	1285.812	1288.987	1292.160	1295.333	1298.504	1301.675	1304.844	1308.013
39	1311.180	1314.347	1317.512	1320.677	1323.840	1327.003	1330.164	1333.325	1336.484	1339.643
40	1342.800	1345.957	1349.112	1352.267	1355.420	1358.573	1371.724	1364.875	1368.024	1371.173
41	1374.320	1377.467	1380.612	1383.757	1386.900	1390.043	1393.184	1396.325	1399.464	1402.603
42	1405.740	1408.877	1412.012	1415.147	1418.280	1421.413	1424.544	1427.675	1430.804	1433.933
43	1437.060	1440.230	1443.398	1446.566	1449.734	1452.900	1456.066	1459.230	1462.394	1465.558
44	1468.720	1471.882	1475.042	1478.202	1481.362	1484.520	1487.678	1490.834	1493.990	1497.146
45	1500.300	1503.454	1506.606	1509.758	1512.910	1516.060	1519.210	1522.359	1525.506	1528.654
46	1531.800	1534.946	1538.090	1541.234	1544.378	1547.520	1550.662	1553.802	1556.942	1560.082
47	1563.220	1566.358	1569.494	1572.630	1575.766	1578.900	1582.034	1585.166	1588.298	1591.430
48	1594.560	1597.690	1600.818	1603.946	1607.074	1610.200	1613.326	1616.450	1619.574	1622.698
49	1625.820	1628.942	1632.062	1635.182	1638.302	1641.420	1644.538	1647.654	1650.770	1653.886
50	1657.000	1660.114	1663.226	1666.338	1669.450	1672.560	1675.670	1678.778	1681.886	1684.994
51	1688.100	1691.206	1694.310	1697.414	1700.518	1703.620	1706.722	1709.822	1712.922	1716.022
52	1719.120	1722.218	1725.314	1728.410	1731.506	1734.600	1737.604	1740.786	1743.878	1746.970
53	1750.060	1753.150	1756.238	1759.327	1762.414	1765.500	1768.586	1771.670	1774.754	1777.838
54	1780.920	1784.002	1787.082	1790.162	1793.242	1796.320	1799.398	1802.474	1805.550	1808.626
55	1811.700	1814.829	1817.957	1821.084	1824.211	1827.338	1830.463	1833.588	1836.713	1839.837
56	1842.960	1846.083	1849.205	1852.326	1855.417	1858.568	1861.687	1864.806	1867.925	1871.043
57	1874.160	1877.277	1880.393	1883.508	1886.623	1889.738	1892.851	1895.964	1899.077	1902.189
58	1905.300	1908.411	1911.521	1914 630	1917.739	1920.848	1923.955	1927.062	1930.169	1933.275
59	1936.380	1939.485	1942.589	1945.692	1948.795	1951.898	1954.999	1958.100	1961.201	1964.301
60	1967.400	1970.499	1973.597	1976.694	1979.791	1982.888	1985.983	1989.078	1992.173	1995.267

XX.

HIRN'S ANALYSIS.

Data and Results.

Test of Steam-engine made by....................at....................

Kind of engine................Diam. cylinder........Length stroke........

Diam. piston-rod....... Vol. cylinder, crank end.......Vol. head end.......

Vol. clearance, cu. ft., head............Clearance in per cent of stroke.......

" " " crank............ " " " ....

Boiler-pressure by gauge............ Barometer.........................

Boiler-pressure absolute............. Boiling temp., atmos. pressure........

Revolutions per hour................. Steam used during run, lbs...........

Quality of steam in steam-pipe....... Quality of steam in steam-chest.......

Quality of steam in compression..... Quality of steam in exhaust..........

Weight of condensed steam per hour..

Pounds of wet steam per stroke...........Head............Crank...........

Temperatures condensed steam..

Temperatures condensing water, cold.................Hot.................

Pounds of condensing water, per hour..............Per stroke..............

Symbols.

To denote different portions of the stroke, the following subscripts are used :

Admission (*a*); expansion (*b*); exhaust (*c*); compression (*d*).

To denote different events of the stroke, the following sub-numbers are used :

Cut-off (1); release (2); compression, beginning of (3); admission, beginning of (0); in exhaust (5).

Quality of steam denoted by X.

Cut-off, crank end per cent of stroke .... Release, crank end............

Cut-off, head end per cent of stroke .... Release, head end.............

Compression, crank end per cent of stroke.... Lbs. steam per I. H. P........

Compression, head end per cent of stroke.... Lbs. steam per brake H. P......

I. H. P................................ Brake horse-power............

XX.—(*Continued.*)

DATA AND RESULTS

PER 100 STROKES.

________________ *Engine.* *Date* ________________ 189

QUANTITIES.	SYMBOL.	FORMULA.	RESULTS	
			Head.	Crank.
Weight steam per 100 strokes, lbs.	M			
Weight of steam in clearance, lbs.	M_0	$\frac{V_0 \text{ (Wt. per cu. ft.)}}{X_0}$.		
Weight of steam, total	$M+M_0$			
Condensing water, lbs.	G			
Heat given to condensing water, B.T.U.	K	$G(S_k - S_i)$.		
Heat supplied engine, B.T.U.	Q	$M(XL + S)$		
Heat retained by compression, B.T.U.	Q_0	$M_0 S_0 + \frac{V_0 I_0}{C_0}$.		
External heat steam at cut-off, B.T.U.	H_1	$(M + M_0)S_1$		
Internal heat steam at cut-off, B.T.U.	H_1'	$(V_0 + V_1)\frac{I_1}{C_1}$.		
Cylinder loss during admission, B.T.U.	Q_a	$Q + Q_0 - H_1 - H_1' - \frac{1}{778}W_a$		
Loss sensible heat during expansion	H_2	$(M + M_0)(S_1 - S_2)$.		
Internal heat after expansion	H_2'	$(V_0 + V_2)\frac{I_2}{C_2}$.		
Cylinder loss during expansion, B.T.U.	Q_b	$H_2 + H_1' - H_2' - \frac{1}{778}W_b$		
Sensible heat at exhaust	H_e	$(M + M_0)S_2$		
External heat at compression	H_3	$M_0 S_3$		
Internal heat at compression	H_3	$(V_0 + V_c)\frac{I_3}{C_3}$.		
Heat delivered from condenser	H_c	MS_d.		
Heat carried off in exhaust	H_4	$M(XL_5 + S_5)$ (per calorimeter)		
Cylinder loss, exhaust, B.T.U.	Q_c	$H_e + H_2' - H_3' - K - H_3 - H_c - \frac{W_e}{778}$		
" " " "	Q_c	$H_e + H_2' - H_3' - H_3 - H_4 - \frac{W_c}{778}$.		
Sensible heat, gain during compression.	H_5	$M_0(S_3 - S_0)$		
Internal heat at admission	H'	$V_0 \frac{I_0}{C_0}$.		
Cylinder loss during compression, B.T.U.	Q_d	$H_5 + H_3' - H' - \frac{W_d}{778}$.		
Heat admitted	Q			
Heat discharged and external work.	B	$H_c + K +$ total $W \div 778$		
Loss	D	$Q - B$		
Loss	D'	$Q_a + Q_b + Q_c + Q_d$		

XXI.

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

	Symbol.	Formula.	Point of Cut-off. Full Stroke.	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Number for Reference.
Effective horse-power to be developed… ..	E	Assumed.	150	150	150	150	150	150	150	150	1
Absolute initial pressure of steam, pounds per square inch. ……	P	Assumed.	100	100	100	100	100	100	100	100	2
Back-pressure, pounds per square inch…..	b	Assumed.	17.5	17.5	17.7	17.5	1.7.5	17.5	17.5	17.5	3
Apparent cut-off………………………	$\frac{1}{r}$	Assumed.	1	.75	.5	.33	.25	.17	.125	.083	4
Absolute pressure at point of cut-off, pounds per square inch. ……	C	Assumed.	90	92.5	95	96.5	97.5	98	98.5	99	5
Clearance at each end, in equivalent length of cylinder, inches. Piston.	(P)	Assumed.	.3125	.3125	.3125	.3125	.3125	.3125	.3125	.3125	6
Clearance at each end, in equivalent length of cylinder, inches. Port.	(p)	Assumed.	.625	.6875	.75	.8125	.875	1	1.0625	1.375	7
Clearance at each end, in equivalent length of cylinder, inches. Total.	f	$(P)+(p)$	.9375	1.	1.0625	1.125	1.1875	1.3125	1.375	1.6875	8
Piston-speed, feet per minute…………….	V	Assumed.	450	450	450	450	450	450	450	450	9
Mean absolute pressure up to cut-off, pounds per square inch………. …..	m	$\frac{P+C}{2}$	95	96.75	97.5	98.25	98.75	99	99.25	99.5	10
Apparent ratio of expansion. ……. …	r	Assumed.	1	1.33	2	3	4	6	8	12	11
Hyperbolic logarithm of apparent ratio of expansion. ….	hyp log r	From tables.	……..	.2877	.6931	1.0986	1.3863	1.7918	2.0794	2.4849	12
Mean effective trial-pressure, pounds per square inch. ………..	T	$\frac{m+C\times \text{hyp log } r}{R}-b.$	77.5	75	64.2	50.6	41	28.3	20.5	11.3	13
Effective horse-power for trial-pressure, each square inch of piston area.	h	$\frac{T\times V}{33{,}000}$	1.057	1.023	.739	.690	.562	386	.280	.154	14
Trial cross-section of cylinder, square inches. ………. ..	a	$\frac{E}{h}$	141.9	142.7	203	217.4	267	388.6	536	974	15
Trial diameter of cylinder, inches, to nearest quarter-inch. ……..	d	$\sqrt{\frac{a}{.7854}}$	13.5	13.5	16	16.5	18.5	22.25	26.25	35.25	16
Trial stroke of piston, inches…………….	s	$2\times d$	27	27	32	33	37	45	52.5	70.5	17
Fraction of clearance…………. ………	F	$\frac{f}{s}$	.0347	.037	.0332	.0341	.0321	.0292	.0262	.0239	18

XXI.—(*Continued.*)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

	Symbol.	Formula.	Point of Cut-off. Full Stroke.	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Number for Reference.
Per cent of clearance to nearest quarter per cent.	c	Assumed from F.	3½	3½	3½	3½	3¼	3	2½	2½	19
Real ratio of expansion	R	$\frac{1+c/100}{1/r+c/100}$	1	1.318	1.935	2.913	3.655	5.228	6.833	9.464	20
Hyperbolic logarithm of real ratio of expansion.	hyp log R	From tables.	......	.2761	.6601	1.0343	1.2961	1.6540	1.9218	2.2475	21
Mean pressure for stroke plus clearance, corrected for back-pressure, pounds per square inch.	M	$\frac{m+C\times \text{hyp log } R}{R}-b$	77.5	75.4	65.3	52.9	44.7	32.4	24.7	16.8	22
Mean pressure corrected for back-pressure and clearance, pounds per square inch.	n	$M-\frac{c}{100}\times(P-M)$	76.7	74.5	64.1	51.3	42.9	30.4	22.8	14.7	23
Ratio of compression. When final cushion-pressure is less than initial pressure.	l	Assumed.	1	1.318	1.935	2.813	3.655	5.228	......	......	24
Ratio of compression. To make final cushion-pressure and initial pressure equal.		$\frac{P}{b}$	......	......	......	......	......	......	5.724	5.714	25
Hyperbolic logarithm of ratio of compression.	hyp log l	From tables.	......	.2761	.6601	1.0343	1.2961	1.6540	1.7429	1.7429	26
Final cushion-pressure, pounds per square inch.	L	$b\times l$	17.5	23.1	33.9	49.2	64	91.5	100	100	27
Mean absolute cushion-pressure, pounds per square inch.	k	$L\times\frac{\text{hyp log } l}{l-1}$	......	20	23.9	28.1	31.2	35.8	37	37	28
Mean pressure, corrected for back pressure, clearance, and cushion, pounds per square inch.	t	$n-\frac{c}{100}\times(l-1)\times(k-b)$	76.7	74.5	63.9	50.6	41.7	28.1	20.5	12.4	29
Probable mean effective pressure, pounds per square inch.	e	$.95\times t$	72.9	70.8	60.7	48.1	39.6	26.7	19.5	11.8	30
Horse-power for pressure e, each square inch of effective piston-area.	H	$\frac{e\times B}{33{,}000}$	.995	.967	.828	.656	.540	.364	.266	.161	31

XXI.—(*Continued.*)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

	Symbol.	Formula.	Point of Cut-off. Full Stroke.	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	Number for Reference.
Effective cross-section of cylinder, square inches.	q	$\frac{E}{H}$	150.8	155.1	181.2	228.7	277.8	412.1	563.9	931.7	32
Actual cross-section of cylinder, square inches for effective section q.	A	$\frac{2q}{e-(.018\times\sqrt{P})^2}$	153.2	157.6	184.1	232.4	282.2	418.7	572.9	946.6	33
Diameter of cylinder, inches to nearest quarter-inch.	D	$\sqrt{\frac{A}{.7854}}$	14	14.25	15.25	17.25	19	23	27	34.75	34
Stroke, inches	S	$2\times D$	28	28.5	30.5	34.5	38	46	54	69.5	35
Diameter of piston-rod, inches to nearest sixteenth-inch.	p	$.018\times D\times\sqrt{P}$	2.5	2.5625	2.75	3.125	3.4375	4.125	4.875	6.25	36
Cross-section of cylinder, square inches, revised value.	(A)	$.7854\times D^2$	153.9	159.5	182.7	233.7	283.5	415.5	5726	948.4	37
Cross-section of piston-rod, square inches	o	$.7854\times p^2$	4.9	5.2	5.9	7.7	9.3	13.4	18.7	30.7	37½
Effective cross-section of cylinder, square inches, revised value.	(q)	$\frac{2\times(A)-o}{2}$	151.5	156.9	179.8	224.9	278.9	408.8	563.3	933.1	38
Probable effective horse-power	(E)	$\frac{e\times(q)\times V}{33{,}000}$	150.6	151.5	148.8	147.5	150.6	148.8	149.8	150.1	39
Clearance in equivalent length of cylinder, inches, revised value	(c)	$\frac{c}{100}\times S$	.98	1.	1.07	1.21	1.24	1.38	1.35	1.74	40
Volume of clearance-space at each end, cubic feet.	N	$\frac{(c)\times(q)}{1728}$	.0859	.0906	.111	.157	.199	.326	.440	.938	41
Volume of cylinder and clearance at one end up to .95 stroke, cubic feet.	v	$\frac{.95\times(q)\times S}{1728}+N$	2.418	2.549	3.126	4.423	6.026	10.665	17.163	36.591	42
Number of strokes per hour	w	$\frac{V\times 12\times 60}{S}$	11571	11368	10623	9391	8526	7043	6000	4662	43
Absolute pressure at .95 stroke, pounds per square inch.	B	$\frac{1/r+c/100}{.95+c/100}\times C$	91 ass'm'd	83	51.6	36.1	28.1	19.7	15.2	11	44
Weight in pounds of a cubic foot of steam at pressure B.	W	From tables.	.2107	.1932	.1223	.08830	.06978	.04998	.04109	.02891	45

XXI.—(*Continued.*)

NON-CONDENSING ENGINE, DRY SATURATED STEAM, UNJACKETED CYLINDER.

	Symbol.	Formula.	Point of Cut-off. Full Stroke.	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$	Number for Reference.
Weight in pounds of a cubic foot of steam at pressure *L*.	w	From tables.	.04472	.05805	08323	.1181	.1513	.2118	.2303	.2303	46
Pounds of steam used hourly, calculated by piston-displacement.	Q	$w \times (v \times W - N \times w)$	5851	5539	3963	3494	3328	3268	3627	3925	47
Mean total pressure during expansion, pounds per square inch.	U	$C \times \frac{\text{hyp log } R}{R - 1}$	....	80.3	67.1	55.1	47.6	38.3	32.2	26.3	48
Ratio of mechanical effect during expansion to total mechanical effect.	I	$\frac{U \times (r - 1)}{r \times (n + b)}$	....	.218	.411	.534	.591	.666	.699	.749	49
Units of heat required hourly for the work of expansion.	i	$\frac{(n + b) \times I \times (q) \times S/12 \times w}{772}$	....	110052	189649	274063	348205	456091	554981	687080	50
Latent heat per pound of steam at pressure *B*, British thermal units.	(l)	From tables.	....	893	916	931	942	955	965	976	51
Pounds of steam condensed hourly for work of expansion.	(C)	$\frac{i}{(l)}$	....	124	207	294	370	477	575	704	52
Thickness of piston, inches, to nearest half-inch.	T	$\sqrt{D}$	3.5	4	4	4	4.5	5	5	6	53
Internal condensing surface, square feet.	(a)	$\frac{2 \times (A)}{144} + 3.1416 \times \frac{D}{12} \times \frac{S + (T) + 2 \times (P)}{12} + 3.1416 \times \frac{p}{12} \times \frac{S + (P)}{12}$	18.9	19.7	22.4	28.4	34.5	50.3	68.7	113.3	54
Probably condensation hourly, on internal surfaces, pounds.	(d)	$15 \times (a)$	284	296	336	426	518	755	1032	1700	55
Probable consumption of steam hourly, pounds — Total..	(w)	$Q + (C) + (d)$	6135	5959	4506	4214	4216	4500	5234	6329	56
Probable consumption of steam hourly, pounds — Per effective horse-power..	(W)	$\frac{(w)}{(E)}$	40.7	39.3	30.3	28.6	28	30 2	34.9	42.2	57

XXI.—(*Continued.*)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS.

	Symbol.	Formula.	Point of Cut-off. Full Stroke.	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$
Mean pressure, pounds per square inch. Corrected for back-pressure	M	22	90.5	88.4	78.3	65.9	57.7	45.4	37.7	29.8
Mean pressure, pounds per square inch. Corrected for back-pressure and clearance	N	23	90.2	88.0	77.5	64.7	56.3	43.8	36.1	28.0
Ratio of compression	l	20	1	1.318	1.935	2.813	3.655	5.228	6.833	9.464
Hyperbolic logarithm of ratio of compression	hyp log l	21	—	.2761	.6601	1.0343	1.2961	1.654	1.9218	2.2475
Final cushion-pressure, pounds per square inch	L	27	4.5	5.9	8.7	12.6	16.4	23.5	30.7	42.6
Mean absolute cushion-pressure, pounds per square inch	k	28	—	5.1	6.1	7.2	8.0	9.2	10.1	11.3
Mean pressure, corrected for back-pressure, clearance and cushion, pounds per square inch	t	29	90.2	88.0	77.4	64 5	56.0	43.2	35.3	26.6
Probable mean effective pressure, pounds per square inch	e	30	85.7	83.6	73.5	61.3	53.2	41.0	33.5	25.3
Probable effective horse-power	(E)	39	177	178.9	180.2	188	202.3	228.6	257.3	321.9
Pounds of steam used hourly. Calculated by piston-displacement	Q	47	5883	5582	4034	3611	3506	3619	4031	4480
Pounds of steam used hourly. Condensed for the work of expansion	(C)	52	—	124	207	294	370	477	575	704
Pounds of steam used hourly. Condensed on internal condensing surfaces	(d)	25 (a)	473	493	560	710	863	1258	1718	2833
Pounds of steam used hourly. Total	(w)	56	6356	6199	4801	4615	4739	5354	6324	8017
Pounds of steam used hourly. Per effective horse-power	(W)	57	35.9	34.7	26.6	24.5	23.4	23.4	24.6	24.8

XXI.—(*Continued.*)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS, 150 EFFECTIVE HORSE-POWER, 100 POUNDS INITIAL PRESSURE, $4\frac{1}{2}$ POUNDS BACK-PRESSURE.

	Symbol.	Formula.	Point of Cut-off.							
			Full Stroke.	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$
Trial data. Mean effective pressure	T	13	90.5	88	77.7	64.1	54.5	41.8	.34	24.8
Trial data. Cross-section of cylinder, square inches	a	15	121.55	125	141.57	171.61	201.84	263.16	323.53	443.55
Trial data. Diameter of cylinder, inches, to nearest $\frac{1}{4}''$	d	16	$12\frac{1}{2}$	$12\frac{1}{2}$	$13\frac{1}{2}$	$14\frac{3}{4}$	16	$18\frac{1}{4}$	$20\frac{1}{4}$	$23\frac{3}{4}$
Trial data. Stroke, inches	s	17	25	25	27	$29\frac{1}{2}$	32	$36\frac{1}{2}$	$40\frac{1}{2}$	$47\frac{1}{2}$
Trial data. Fraction of clearance	F	18	.0375	.0400	.0394	.0381	.0311	.0355	.0340	.0355
P r cent of clearance to nearest $\frac{1}{4}''$	c	19	$3\frac{3}{4}$	4	4	$3\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$
Real ratio of expansion and ratio of compression	$R.\ l$	20, 24	1	1.3165	1.9259	2.7978	3.6087	5.1322	6.4687	8.7465
Hyperbolic logarithm of preceding	hy log R	From tabl's	—	.2753	.6554	1.0289	1.2834	1.6355	1.867	2.1686
Probable mean effective pressure	e	30	85.6	83.4	73.6	61.4	52.7	41.2	34.4	25.8
Diameter of cylinder, inches, to nearest $\frac{1}{4}''$	D	34	13	$13\frac{1}{4}$	14	$15\frac{1}{4}$	$16\frac{1}{2}$	$18\frac{1}{2}$	$20\frac{1}{4}$	$23\frac{1}{2}$
Stroke, inches	S	35	26	$26\frac{1}{2}$	28	$30\frac{1}{2}$	33	37	$40\frac{1}{2}$	47
Diameter of piston-rod, inches, to nearest $\frac{1}{16}''$	p	36	$2\frac{5}{16}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{5}{16}$	$3\frac{5}{8}$	$4\frac{1}{4}$
Cross-section of cylinder, square inches. Actual	(A)	37	132.73	137.89	153.94	182.65	213.83	268.8	322.06	433.74
Cross-section of cylinder, square inches. Effective	(q)	38	130.63	135.67	151.48	179.68	210.29	264.49	316.9	426.64
Probable effective horse-power	(E)	39	152.5	154.3	152	150.4	151.1	148.6	148.7	150.1
Volume, cubic feet. Cylinder and clearance, up to $\frac{95}{100}$ stroke	v	42	.941	.06	2.43	3.132	3.966	5.578	7.316	11.309
Volume, cubic feet. Clearance	N	41	.0737	.0832	.0982	.119	.151	.198	.26	.402
Absolute pressures. Final cushion	L	27	4.5	5.9	8.7	12.6	16.2	23.1	29.1	39.4
Absolute pressures. At $\frac{95}{100}$ stroke	B	44	91	73.8	51.8	36.2	28.4	20.1	16	11.9
Number of strokes per hour	w	43	12752	12226	11571	10623	9818	.8759	8000	6968

XXI.—(*Continued.*)

CONDENSING ENGINES, DRY SATURATED STEAM, UNJACKETED CYLINDERS, 150 EFFECTIVE HORSE-POWER, 100 POUNDS INITIAL PRESSURE, $4\frac{1}{2}$ POUNDS BACK-PRESSURE.—(*Continued.*)

	Symbol.	Formula.	Point of Cut-off.							
			Full stroke.	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{6}$	$\frac{1}{8}$	$\frac{1}{12}$
Weight of steam per cubic foot, pounds. At pressure L	w	From tables	.01249	.0161	.02319	.03285	.04159	.05805	.07211	.09586
Weight of steam per cubic foot, pounds. At pressure B	W	From tables	.2107	.173	.124	.08603	.07048	.05093	.04111	.03113
Pounds of steam hourly, calculated by piston-displacement	Q	47	5203	4330	3460	2821	2683	2387	2256	2185
Latent heat per pound of steam at pressure B. British thermal units	(l)	From tables	—	899	916	931	941	955	963	973
Pounds of steam condensed hourly for work of expansion	(C)	52	—	106	194	249	281	313	339	390
Thickness of piston, inches, to nearest $\frac{1}{2}''$	(T)	53	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$	5
Internal condensing surface, square feet	(a)	54	16.3	16.9	18.8	22.4	25.8	32.8	39.1	52.1
Probable condensation, hourly, on internal surfaces, pounds	(d)	25×(a)	408	424	471	561	645	819	976	1304
Probable consumption of steam, hourly, pounds. Total	(w)	56	5611	4860	4125	3631	3609	3519	3571	3879
Probable consumption of steam, hourly, pounds. Per effective horse-power	(W)	57	36.8	31.5	27.1	24.1	23.9	23.7	24	25.8

XXI.—(*Continued.*)

NON-CONDENSING ENGINES, DRY SATURATED STEAM-JACKETED CYLINDERS.

	Symbol.	Formula.	Point of Cut-off. Full Stroke	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Number for Reference.
Sixteenth root of real cut-off..	$\left(\frac{1}{R}\right)^{\frac{1}{16}}$	$\left(\frac{1}{R}\right)^{\frac{1}{16}}$	1	.98287	.95960	.93747	.92219	.90169	.88682	.87031	58
Mean pressure for stroke, plus clearance, corrected for back-pressure, pounds per square inch.	M	$\frac{m + 16 \times C \times \left[1 - \left(\frac{1}{R}\right)^{\frac{1}{16}}\right]}{R} - b$	77.5	74.7	64.6	51.8	42.7	30.8	23.1	15.3	59
Ratio of compression. When final cushion-pressure is less than initial pressure.	l	Assumed.	1	1.3185	1.9346	2.81	3.6549	......	......	......	60
Ratio of compression. To make final cushion-pressure and initial pressure equal.		$\left(\frac{P}{b}\right)^{\frac{16}{17}}$	.....	......	... ..	.. ...	......	5.1574	5.1574	5.1574	61
Seventeenth power of sixteenth root of ratio of compression. ..	$l^{\frac{17}{16}}$	$l^{\frac{17}{16}}$	1	1.341	2.016	2.997	3.963	5.808	5.808	5.808	62
Final cushion-pressure, pounds per square inch.	L	$b \times l^{\frac{17}{16}}$	17.5	23.5	35.3	52.5	69.4	100	100	100	63
Sixteenth root of reciprocal of ratio of compression.	$\left(\frac{1}{l}\right)^{\frac{1}{16}}$	$\left(\frac{1}{l}\right)^{\frac{1}{16}}$	1	.98287	.95960	.93747	.92219	.89587	.89587	.89587	64
Absolute cushion-pressure, pounds per square inch.	k	$L \times \frac{16 \times \left[1 - \left(\frac{1}{l}\right)^{\frac{1}{16}}\right]}{l - 1}$	......	20.2	24.4	29.	32.5	37.5	37.5	37.5	65
Ratio of expansion up to .95 stroke.	—	$\left(\frac{\frac{1}{r} + \frac{c}{100}}{.95 + c/100}\right)^{\frac{17}{16}}$	.....	.786	.523	.352	.266	.182	.137	.0969	66
Absolute pressure at .95 stroke, pounds per square inch.	B	$C \times \left(\frac{1/2 + c/100}{.95 + c/100}\right)^{\frac{17}{16}}$	91 ass'd.	72.7	49.7	34.	25.9	17.8	13.5	9.6	67
Weight in pounds of a cubic foot of steam at pressure B.	W	From tables.	2107	.1705	.1193	.08346	.06464	.04544	.03505	.02544	68
Weight in pounds of a cubic foot of steam at pressure L.	w	From tables.	.04472	.05899	.08646	.1256	.1633	.2303	.2303	.2303	69

XXI.—(*Continued.*)

NON-CONDENSING ENGINES, DRY SATURATED STEAM-JACKETED CYLINDERS.

	Symbol.	Formula.	Point of Cut-off. Full Stroke	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Number for Reference.
Felted surface, square feet	(a)	Assumed.	18.9	19.7	22.4	28.4	34.5	50.3	68.7	113.3	70
Unfelted surface, square feet	(f)	$2 \times \frac{(A)}{144} + 3.1416 \times \frac{p}{12} \times \frac{S+(P)}{12}$	3.7	3.9	4.4	5.7	6.9	10.1	13.8	22.9	71
External temperature of jacket, Fahr.	(t)	Assumed.	70°	70°	70°	70°	70°	70°	70°	70°	72
Internal temperature of jacket, Fahr.	(T)	From tables.	328°	328°	328°	328°	328°	328°	328°	328°	73
Latent heat of steam in jacket, British thermal units per pound.	(L)	From tables.	884	884	884	884	884	884	884	884	74
Heat lost by condensation hourly, British thermal units.	Q	$1.1 \times \{(a) \times [(T)-(t)] \times .5 + (f) \times [(T)-(t)] \times 2.5\}$	5307	5563	6300	8074	9791	14304	19359	32325	75
Probable amount of steam condensed in jacket hourly, pounds.	(K)	$\frac{(Q)+1.1 \times i}{(L)}$	6	143	243	350	444	595	713	892	76
Probable consumption of steam hourly, lbs.	(w)	$Q+(K)$	5857	5023	4103	3631	3488	3479	3714	4225	77

	Symbol.	Point of Cut-off. Full Str'ke	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Ref. No.
Mean pressure, corrected for back-pressure and clearance, pounds per square inch.	n	76.7	73.8	63.4	50.1	40.8	28.7	21.2	13.2	23
Mean pressure, corrected for back-pressure, clearance, and cushion, pounds per square inch.	t	76.7	73.8	63.2	49.4	39.5	26.2	19.1	11.1	29
Probable mean effective pressure, pounds per square inch	e	72.9	70.1	60	46.9	37.5	24.9	18.1	10.5	30
Probable effective horse-power	(E)	150.6	150	147.1	143.8	142.6	139.4	139	133.6	39
Pounds of steam used hourly, calculated by piston-displacement	Q	5851	4880	3860	3281	3044	2884	3001	3333	47
Probable consumption of steam hourly, per effective horse-power pounds	(W)	38.9	33.5	27.9	25.2	24.5	25.1	26.7	31.6	57

XXI.—(*Continued.*)

CONDENSING ENGINES—JACKETED CYLINDERS—DRY SATURATED STEAM.

		Symbol.	Formula.	Point of Cut-off.							
				Full stroke	¾	½	⅜	¼	⅙	⅛	$\frac{1}{12}$
Mean pressure, pounds per square inch.	Corrected for back-pressure	M	59	90.5	87.7	77.6	64.8	55.7	43.8	36.1	28.3
	Cushion	k	65	......	5.2	6.3	7.5	8.4	9.7	10.8	12
	Corrected for back-pressure, clearance, and cushion	t	29	90.2	87.3	76.7	63.4	54	41.4	33.6	24.8
	Probable effective	e	30	85.7	82.9	72.9	60.2	51.3	39.3	31.9	23.6
Probable effective horse-power		(E)	39	177	177.3	178.7	184.6	195.1	219.1	245	300.3
Pounds of steam hourly.	By piston-displacement	Q	47	5883	4924	3933	3415	3244	3264	3385	3838
	Condensed in jacket	(K)	76	5	141	263	356	426	554	675	950
	Total	(w)	77	5888	5065	4196	3771	3670	3818	4060	4788
	Per effective horse-power	(W)	57	33.3	28.6	23.5	20.4	18.8	17.4	16.5	15.9

NON-CONDENSING ENGINES—UNJACKETED CYLINDERS—STEAM SUPERHEATED SUFFICIENTLY TO PREVENT CONDENSATION.

	Symbol	Formula.	Point of Cut-off.								Ref. No.
			Full Str'ke	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	
Terminal pressure, pounds per square inch	(r)	$C \times \frac{1}{R}$	......	70.1	49.1	34.4	26.7	18.7	14.4	10.7	78
Volume of 1 lb. of steam, cubic feet. Atmos. pressure (r)	(v)	From tables.	......	6.07	8.49	11.84	15.04	21.02	26.89	35.56	79
" " " " " " " *m.*	(o)	From tables.	......	4.48	4.45	4.41	4.39	4.38	4.37	4.36	80
Mechanical effect of 1 lb. of steam, during expansion, foot-lbs.	(P)	$[(v) - (o)] \times U \times 144$	......	18386	58361	66959	73342	91552	104328	118161	81
Units of heat condensed for work, per lb. of steam	(p)	$\frac{(P)}{772}$	......	23.8	75.6	86.7	95	119	135	153	82
Total heat, British thermal units per lb., above 32°. Fah., of steam at pressure (r): Saturated steam	(H)	From tables.	......	1174.3	1167.3	1160.5	1156	1150	1146	1142	83
Steam superheated to prevent condensation due to work	(h)	$(H) + (p)$	......	1198.1	1242.9	1247 2	1251	1269	1281	1295	84
Temperature, Fah., of superheated steam, including 50° of superheat to prevent condensation due to radiation	N	$\frac{(h) - 1075}{.4805} + 32 + 50 + 20.403 \times \sqrt[4]{r}$	378°	397°	485°	490°	495°	528°	540°	587°	85
Degrees of superheat, Fahrenheit	(S)	$N - (I)$	50°	69°	157°	162°	167°	200°	212°	259°	86

XXI.—(*Continued.*)

NON-CONDENSING ENGINES, UNJACKETED CYLINDERS, STEAM SUPERHEATED SUFFICIENTLY TO PREVENT CONDENSATION.

		Symbol.	Point of Cut-off. Full Str'ke	¾	½	⅓	¼	⅙	⅛	$\frac{1}{12}$	Ref. No.
Probable effective horse-power.		(*E*)	150.6	151.5	148.8	147 5	150.6	148.8	149.8	150.1	39
Pounds of steam used hourly, calculated by piston-displacement.	Total..	*Q*	5851	5539	3963	3494	3328	3268	3627	3925	47
	Per effective H. P..	(*W*)	38.8	36.6	26.6	23.7	22.1	22	24.2	26.1	57

Point of Cut-off.	Pounds of steam hourly.	Effective horse-power.	Pounds of steam hourly, per effective horse-power.
Full stroke.	5883	177	33.2
¾	5582	178.9	31.2
½	4034	180.2	22.4
⅓	3611	188	19.3
¼	3506	202.3	17.3
⅙	3619	228.6	15.9
⅛	4031	257.3	15.7
$\frac{1}{12}$	4480	321.9	13.9